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RESEARCH IN CHINA

IN THREE VOLUMES AND ATLAS

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VOLUME THREE

THE CAMBRIAN FAUNAS OF CHINA

By Charles D. Walcott

A REPORT ON ORDOVICIAN FOSSILS COLLECTED IN EASTERN ASIA IN 1903-04

By Stuart Weller

A REPORT ON UPPER PALEOZOIC FOSSILS COLLECTED IN CHINA IN 1903-04

By George H. Girty

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THE CAMBRIAN FAUNAS OF CHINA

By Charles D. Walcott

(With 24 Plates and 9 Text-Figures.)

PREFACE.

When looking over the descriptions of the stratigraphic sections of the Paleozoic formations of China by Baron Ferdinand von Richthofen [China, 1882, vol. 2] and their contained Cambrian fossils described by Dr. W. Dames [China, 1883, vol. 4, pp. 1–33] from Liau-tung, and Dr. Emanuel Kayser [pp. 34–36], I was impressed with the necessity of having the stratigraphic sections studied in detail, and extensive collections of fossils made, in order that comparisons of value might be instituted between the Cambrian sections and faunas of the western portion of North America and the Paleozoic sections and their contained faunas in eastern Asia. This project was held in abeyance for eighteen years, and had it not been for the support of the Carnegie Institution of Washington it might not have been consummated.

Dr. Bailey Willis has given, in the preface of volume 1, part 1, of "Research in China," 1907, a brief statement of the events that led to the sending of an expedition in his charge and the securing of data and collections by him and his associate geologist, Mr. Eliot Blackwelder.

On the return of Messrs. Willis and Blackwelder, I made a preliminary study of the Cambrian fossils and submitted to them the results of the study bearing on the interpretation of the various geological sections in which the fossils occurred. These were included in their description and discussion of the stratigraphy of Shan-tung, Shan-si, and Shen-si. Mr. Blackwelder also made a rapid reconnaissance of the southwestern portion of the province of Liau-tung, Manchuria, and identified certain Cambrian formations, but did not find any fossils.

From the collections made by Baron von Richthofen, it was evident that a considerable Cambrian fauna existed in the western part of Liau-tung, so I delayed final publication of the description and discussion of the Cambrian collections made by Messrs. Willis and Blackwelder, in the hope that material could be secured from that region. Learning in the spring of 1909 that Prof. Joseph P. Iddings, of the University of Chicago, was about to visit Japan and China in connection with his study of eruptive rocks, I induced him to visit Manchuria and make a collection of Cambrian fossils for the Smithsonian Institution from the island of Tschang-hsing-tau, east of Niang-niang-kung, in the province of Liau-tung. He was so fortunate as to secure the services of Li San, Dr. Bailey Willis's interpreter, who was also a good collector, and they obtained a large number of specimens, representing over fifty species of invertebrate fossils.

Wishing to have better illustrations of the species described by Messrs. Dames and Kayser for Baron von Richthofen, I wrote to Prof. W. Branco,

Director of the Royal Geological and Paleontological Institute and Museum at Berlin, who very kindly had photographs made for me of all the specimens illustrated by Doctor Dames that could be identified in the collections.

Through the courtesy of Dr. Wilhelm Deecke, of the Geological Institute of the University of Freiburg, I have had the opportunity of studying most of the specimens from China used for illustration by Dr. Th. Lorenz [1906]. This enabled me to make identifications that otherwise would have been very difficult, owing to the fragmentary character of the specimens illustrating the trilobites.

The chief results obtained from the study of the Chinese collections are the discovery of portions of the upper part of the Lower Cambrian fauna and a great development of a Middle Cambrian fauna of the same general character as that of the Cordilleran Province of western North America; also an Upper Cambrian fauna comparable with that of the Cordilleran Province and the Upper Mississippi Province of the United States. The fauna of the upper zone of the Lower Cambrian was found to be of the same general type as that of the Cambrian fauna of the Salt Range of India, and we were thus enabled definitely to locate the faunal horizons in India which have heretofore been referred to Upper Cambrian and post-Cambrian formations.

Another important discovery was that of the occurrence in the Middle Cambrian of China of a fauna comparable with that of the Middle Cambrian of Mount Stephen, British Columbia, and the southern extension of the same fauna in the Middle Cambrian of Idaho, Utah, and Nevada in the United States.

The determination of the age of the Man-t'o shales affords the data by which to fix the period of Cambrian time in which the Cambrian sea transgressed over eastern and southeastern Asia, and shows that it was somewhat later than the transgression in the Siberian area now occupied by the basins of the Lena and Yenesei rivers.

A noteworthy addition to the knowledge of the Cambrian faunas was the discovery for the first time of a true cephalopod in a fauna referred to the Upper Cambrian. This is illustrated by a species of *Cyrtoceras*, which occurs in the lower part of the Ch'au-mi-tién limestone. Other details will be found in the discussion of the subfaunas and their stratigraphic and geographic distribution.

From the study of the collections described in this memoir I anticipate that a large and varied fauna will soon be found in the Cambrian formations of China. What we now have is the result of hurried and superficial collecting. Persistent search by trained collectors will undoubtedly give material comparable in extent and beauty with that of America and Europe, and add many unique genera and species to the great Cambrian fauna.

CHARLES D. WALCOTT.

April 26, 1913.

THE CAMBRIAN FAUNAS OF CHINA.

HISTORICAL REVIEW.

The presence of Cambrian fossils in China was first announced by Baron von Richthofen in 1883 [China, vol. IV]. The material gathered by him was studied by Dr. E. Kayser, to whom the brachiopods were intrusted, and by Dr. W. Dames, who described the trilobites.

Doctor Kayser described and named the following brachiopods [1883, pp. 34–35]: *Orthis linnarssoni = Eoorthis linnarssoni; Lingulella* sp.; *L.* sp. Of these, we have identified *Eoorthis linnarssoni* from the collections of the Carnegie Institution of Washington Expedition to China.

Doctor Dames described and named the following trilobites [1883, pp. 7–29]:

Agnostus chinensis	*Anomocare latelimbatum*	*Liostracus megalurus*
Dorypyge richthofeni	*Anomocare majus*	*Liostracus talingensis*
Conocephalites frequens	*Anomocare minus*	*? Liostracus*
Conocephalites quadriceps	*Anomocare nanum*	*? Liostracus*
Conocephalites subquadratus	*Anomocare planum*	Two pygidia, gen. and sp. undt.
Conocephalites typus	*Anomocare subcostatum*	

The material described by Doctor Dames came from three localities in Liau-tung, as follows:

Sai-ma-ki (in situ):

Lingulella	*Conocephalites quadriceps*	*Anomocare nanum*
Agnostus chinensis	*Anomocare latelimbatum*	*Anomocare subcostatum*
Conocephalites frequens	*Anomocare majus*	

Ta-ling (loose rock in wall):

Dorypyge richthofeni	*Conocephalites typus*	*Liostracus talingensis*
Conocephalites frequens	*Anomocare minus*	*Liostracus* sp. ?
Conocephalites subquadratus	*Anomocare nanum*	

Wu-lo-pu (débris slope):

Dorypyge richthofeni	*Anomocare planum*	*Liostracus megalurus*

Of the above we have identified in our collections:

Agnostus chinensis	*Anomocare latelimbatum*
Dorypyge richthofeni	*Anomocare minus*
Conocephalites subquadratus = Anomocare	*Liostracus megalurus = Anomocare*
Conocephalites typus = Ptychoparia	

Doctor Dames compared the Cambrian trilobites with those of Europe, America, and India, and concluded that the trilobitic fauna of Sai-ma-ki and Ta-ling was about the age of the Scandinavian Andrarum limestone and the Potsdam group of North America. He did not find any Chinese species that could be identified with those of Scandinavia and America, but the general appearance of the fauna as a whole was so similar that he considered their

equal age proven. He further states that the age of the rocks containing *Dorypyge richthofeni*, from Wu-lo-pu, is probably the same as that of the Quebec group, basing this upon comparisons with species from Utah, which he referred to the genus *Dorypyge* [China, Richthofen, vol. IV, pp. 31–33].

The collections made by the Carnegie Institution of Washington Expedition prove that *Dorypyge richthofeni* occurs in the central and upper portion of the Ch'ang-hia formation and is of Middle Cambrian age. Baron von Richthofen's means of comparison were with the fauna referred to the Quebec group which was at that time supposed to be of Lower Silurian (Ordovician) age.

Dr. C. Gottsche, in 1886, called attention to the presence of Cambrian rocks and fossils in northwestern Korea, south of Wi-wön. He published a geological section and identified *Anomocare planum* Dames, *Anomocare majus* Dames, *Dorypyge richthofeni* Dames, and *Lingulella* cf. *nathorsti* Linnarsson. He also mentions the genera *Theca*, *Orthis*, *Lingulella* (two species), *Agnostus*, *Conocephalites*, *Crepicephalus*, and *?Remopleurides*, and correlates the formation with that of the "Andrarum limestone" of Scandinavia [Gottsche, 1886, pp. 865–867].

In 1899 M. Bergeron [pp. 499–516] described the following Cambrian fossils from shaly limestones collected in the province of Shan-tung, China:

Agnostus douvilléi	*Drepanura premesnili*	*Dicellocephalus ? sinensis*
Olenoides leblanci	*Arthricocephalus chauveaui*	*Calymmene ? sinensis*

Of the above we have identified the following from the Ku-shan shale of the section made by Mr. Blackwelder:

Agnostus douvilléi
Olenoides leblanci
Drepanura premesnili
Dicellocephalus ? sinensis = *Stephanocare*
Calymmene ? sinensis = *Blackwelderia*

From the Cambrian formations of Siberia, Dr. Fr. Schmidt [1886, pp. 407–424] described the following fossils:

Agnostus czekanowskii
Proetus (Phaeton) slatkowskii = *Dorypyge*
Cyphaspis sibirica = *Solenopleura*
Liostracus ? maydeli = *Anomocarella*
Anomocare pawlowskii = *Anomocarella*

This fauna was subsequently reviewed by Eduard von Toll [1899, pp. 21–57], who added the following:

Confervites primordialis Bornemann
Archæocyathus acutus Bornemann
Archæocyathus aduncus Bornemann
Archæocyathus ijizkii von Toll
Archæocyathus patulus Bornemann
Archæocyathus proskurjakowi von Toll
Archæocyathus sibiricus von Toll
Coscinocyathus calathus Bornemann
Coscinocyathus campanula Bornemann
Coscinocyathus corbicula Bornemann
Coscinocyathus dianthus Bornemann
Coscinocyathus elongatus Bornemann
Coscinocyathus irregularis von Toll
Coscinocyathus vesica Bornemann
Coscinocyathus cf. *cancellatus* Bornemann
Spirocyathus sp. undt.
Rhabdocyathus sibiricus von Toll
Protopharetra sp. undt.
Helminthoidichnites sp.
Kutorgina cingulata Billings
? Obolella chromatica Billings
Hyolithes sp. undt.
Microdiscus kochi von Toll
Microdiscus lenaicus von Toll
Microdiscus sp. undt.
Agnostus schmidti von Toll

? Olenellus sp. undt.
Dorypyge slatkowskii Schmidt
Ptychoparia czekanowskii von Toll = *Inouyia*
Ptychoparia meglitzkii von Toll = *Inouyia*
? Solenopleura sibirica Schmidt
Bathyuriscus howelli Walcott

In 1903 Dr. H. Monke published a paper on the Geology of Shan-tung and described certain "Upper Cambrian" trilobites,[1] as follows:

Agnostus koerferi
Liostracina krausei
Teinistion lansi
Teinistion sodeni
Drepanura premesnili
Drepanura ketteleri
Stephanocare richthofeni
Stephanocare sp.

Of the above, three genera and species described by me in 1905 are synonyms:

Ptychoparia ceus Walcott . . . . . = *Liostracina krausei* Monke
Dorypygella typicalis Walcott . . . . . = *Teiniston lansi* Monke
Damesella chione Walcott . . . . . = *Stephanocare richthofeni*

The following have not been identified in the material collected by Willis and Blackwelder:

Drepanura ketteleri Monke
Teinistion sodeni Monke

I do not find that *Agnostus koerferi* Monke differs materially from *Agnostus chinensis* Dames, except in the unattached pygidium.

Teinistion lansi Monke is similar in many respects to *Shantungia spinifera* Walcott, but differs in the presence of an incurved frontal margin, and the absence of the long frontal spine.

The detailed sections and the succession of the contained faunas prove that the horizon of the fauna is in the upper part of the Middle Cambrian, and not Upper Cambrian, as determined by Monke.

In 1904 Dr. Th. Lorenz [1904, pp. 193–194] described some problematical fossils? as Algæ under the new family Ascosomaceæ of the Siphoneæ. The genus *Ascosoma* was proposed to include one species, *Ascosoma phaneroporata*, and a second species was placed under a new genus as *Mitscherlichia chinensis*. Doctor Lorenz stated that he would soon publish a full description, with illustrations, of the new family, genera, and species, but on further study he decided that the fauna was neither Algæ nor sponges [Lorenz, 1905, pp. 12, 13].

In 1905 some of the results of the Carnegie Institution of Washington Expedition to China were published by the writer, and a second paper appeared in 1906.[2] These two papers included descriptions and certain introductory notes on the Cambrian fossils collected by Messrs. Bailey Willis and Eliot Blackwelder that are included in this memoir. Subsequently lists of the species appeared in the report on the stratigraphic geology by Messrs. Willis and Blackwelder.[3]

[1] Beiträge zur Geologie von Schantung: I. Obercambrische Trilobiten von Yen-tsy-yai. Jahrb. Königl. Preuss Geol. Landesanstalt und Bergakademie zu Berlin, vol. XXIII, Pt. I, 1903, pp. 103–151.
[2] Proc. U. S. National Museum, vol. XXIX, 1905, pp. 1–106; Idem, vol. XXX, 1906, pp. 563–595.
[3] Research in China, Pt. I, pp. 19–43, 136–147, 272.

Dr. Henry Woodward reviewed, in 1905, the work of Dr. H. Monke[1] and discussed some of the species occurring in a collection of fossils obtained from "West Shan-tung, and south of Tsing-tshou-fu, 36° 40′ N. lat., 118° 40′ E. long." A slab of the fossils from near Yen-tsy-yai is illustrated.

Late in 1906 a short memoir by Dr. Th. Lorenz appeared[2] in which he described a number of new genera and species of Cambrian fossils collected by him in the province of Shan-tung and assigned stratigraphic horizons to them.

The fauna from Lai-wu was worked out of a single block found loose in the bed of a brook about 9 km. west of Lai-wu. Lorenz concludes that the fauna represents the time of the base of the Swedish Andrarum limestone, within the limits of the zone with *Paradoxides davidis* and *P. forchhammeri*.[3] The list of species given by him is as follows:

Olenoides (*Dorypyge*) *richthofeni* (Dames)
Agnostus fallax laiwuensis n. var.
Agnostus parvifrons Linnarsson
Anomocare commune n. sp.
Anomocare ovatum n. sp.
Alokistocare sp.
Amphoton steinmanni n. g. and sp.
Ptychoparia (*Solenopleura*) sp.
Hyolithes sp.
Rhaphistoma bröggeri Grönwall
Acrothele bohemica (Barrande)

From the descriptions and illustrations I have identified the above as follows:

Olenoides (*Dorypyge*) *richthofeni* (Dames) . . . . . = *Dorypyge richthofeni* Dames
Agnostus fallax laiwuensis Lorenz . . . . . = *Agnostus chinensis* Dames
Agnostus parvifrons Linnarsson . . . . . = *Agnostus* cf. *parvifrons* Linnarsson
Anomocare commune Lorenz . . . . . = *Anomocarella chinensis* Walcott
Anomocare ovatum Lorenz . . . . . = *Amomocare temenus* Walcott
Alokistocare sp. (not illustrated or described)
Amphoton steinmanni Lorenz . . . . . = *Dolichometopus deois* Walcott
Rhaphistoma bröggeri Lorenz . . . . . = *Platyceras willisi* Walcott
Acrothele bohemica Barrande . . . . . = *Acrothele matthewi eryx* Walcott

The horizon of the *Dorypyge richthofeni* fauna in Shan-tung was definitely established by Messrs. Willis and Blackwelder as in the Middle Cambrian below the central part of the Kiu-lung group.[4] In Shan-si the fauna occurs in an oolitic limestone that, by its fauna, is related to the Ch'ang-hia oolite.[5]

The fauna from Wang-tschuang occurs at three horizons. It is listed by Doctor Lorenz as follows:[6]

A lower layer with (*a*):
Anomocare speciosum Lorenz
Bathyuriscus asiaticus Lorenz
Agnostus fallax Linnarsson
Agnostus parvifrons latelimbatus Lorenz
Acrothele granulata Linnarsson

Eighty meters higher up, a layer with (*b*):
Teinistion (?) sp.
Drepanura (?) sp.

At 80 meters above, an upper layer has (*c*):
Shantungia buchruckeri Lorenz
Liostracus latus Lorenz

[1] On a collection of trilobites from the Upper Cambrian of Shantung, North China. Geological Magazine, London, new ser., Dec. V, vol. II, 1905, pp. 211–215, 251–255, plate XIII.

[2] Beiträge zur Geologie und Palæontologie von Ostasien unter besonderer Berücksichtigung der Provinz Schantung in China. II, Palæontologischer Teil. Von Herrn Th. Lorenz in Marburg a. d. Lahn. Hierzu Taf. IV–VI u. 55 text fig.

[3] Lorenz, 1906, p. 91. [4] Blackwelder, 1907, p. 40. [5] Idem, p. 145. [6] Lorenz, 1906, p. 93.

I have identified the above-listed fossils as follows:

(*a*) *Anomocare speciosum* Lorenz · · · · · · · · · · · = *Anomocarella speciosa* (Lorenz)
Bathyuriscus asiaticus Lorenz · · · · · · · · · · · = *Dolichometopus deois* Walcott
Agnostus fallax Linnarsson · · · · · · · · · · · · = *A. chinensis* Dames
Agnostus parvifrons latelimbatus Lorenz · · · · = *A. latelimbatus* (Lorenz)
Acrothele granulata Linnarsson · · · · · · · · · · = *Acrothele matthewi eryx* Walcott
(*b*) *Teinistion* (*?*) sp. · · · · · · · · · · · · · · · · · = *Damesella* cf. *blackwelderi* Walcott
Drepanura (*?*) sp. · · · · · · · · · · · · · · · · · · = *Damesella* cf. *blackwelderi* Walcott
(*c*) *Shantungia buchruckeri* Lorenz · · · · · · · · · = *Chuangia nitida* Walcott
Liostracus latus Lorenz · · · · · · · · · · · · · · · = *L. latus* Lorenz

By comparison with the sections of Messrs. Willis and Blackwelder fauna (*a*) is located in the lower portion of the Kiu-lung group at about the same horizon as the fauna from Lai-wu; fauna (*b*) represents the zone of *Damesella blackwelderi* Walcott, which occurs in the central part of the Kiu-lung group; and fauna (*c*), or the upper fauna, may be assigned to the upper limestone of the Kiu-lung group, where the Upper Cambrian fauna is well developed.[1]

At the locality of Tai-shan south of Tsi-nan Doctor Lorenz found fragments of a trilobite that he named *Lioparia blautoeides*, which I have identified as *Anomocarella baucis* Walcott, which occurs near the summit of the Upper Cambrian Ch'au-mi-tién limestone.

At the locality of Tsing-tshou-fu he reports the following:[2]

Lioparia latelimbata (Dames)	*Obolella nitida* n. sp.[3]
Shantungia crassa n. g. and sp.	*Orthis* sp.
A not closely definable brachiopod	*Acrothele* sp.

My identification of the fauna is as follows:

Lioparia latelimbata (Dames) Lorenz · · = *Anomocare latelimbatum* Dames
Shantungia monkei Lorenz · · · · · · · · · = *Pagodia monkei* (Lorenz)
Obolella gracilis Lorenz · · · · · · · · · · · = cf. *Obolus obscurus* Walcott
Orthis sp. and *Acrothele* sp.

I do not find any statement of Doctor Lorenz that the species enumerated by him were found in association. They do not appear to have come from the same stratigraphic horizon. *Pagodia monkei* (Lorenz) is essentially an Upper Cambrian type, while *Anomocare latelimbatum* Dames is from the Middle Cambrian.

I have not attempted to follow the classification of the trilobites given by Doctor Lorenz which is largely based on the division of the shell structure into non-porous (dense) and porous. The mineralization of most of the specimens is such that it is often impracticable to determine with any degree of satisfaction whether the shell is non-porous (dense) or porous.

By the courtesy of Dr. W. Deecke, of the Geological Institute of the University of Freiburg, I received eight pieces of the rock containing original

[1] Willis and Blackwelder, 1905, pp. 23, 41. [2] Lorenz, 1906, p. 95.
[3] This is described as *Obolella gracilis* n. sp., on p. 88 of Lorenz, 1906.

specimens studied by Lorenz. These did not include the types of *Liostracus latus*, *Shantungia buchruckeri*, *Obolella gracilis*, or the specimens referred to *Drepanura* and *Teinistion*. I have had three of the specimens photographed (plate 7, fig. 1*a*; plate 20, fig. 8; plate 22, figs. 2, 2*a*, 2*b*), so that more direct comparison may be made. The original of *Shantungia monkei* Lorenz is too unsatisfactory to photograph.

The student of the Cambrian formations and faunas of China should consult the fine memoir of Dr. Eduard von Toll, 1899, on the Siberian Cambrian. It has many suggestions that the future student of the Cambrian system in Asia should carefully consider. One of them is that a great and important work awaits the investigator of the Cambrian formations of Siberia. The field is a large one and what we now know of it indicates a rich reward to the individual who takes the time to thoroughly work out the formations and their contained faunas.

Mr. F. R. Cowper Reed, in discussing the pre-Carboniferous life provinces of Asia, points out that the Cambrian fauna of Spiti in northern India has a stronger affinity with that of western North America than with any other Cambrian fauna[1] [Reed, 1910]. The bearings of this are not enlarged upon further than to indicate a connection between the Himalayan region and North America during Middle Cambrian time.

[1]Record s Geol. Surv. India, vol. XL, plate 1, 1910, p. 10.

SYNONYMIC REFERENCES.

The following table mentions only those genera and species in which changes have been made since the publication of the original description and reference:

Former generic reference.	*Present generic reference.*
Agnostus koerferi Monke, 1903	*Agnostus douvilléi* Bergeron
Agraulos abaris Walcott, 1905	*Inouyia abaris* (Walcott)
Agraulos acalle Walcott, 1905	*Inouyia ? acalle* (Walcott)
Agraulos agenor Walcott, 1905	*Levisia agenor* (Walcott)
Agraulos armatus Walcott, 1906	*Inouyia ? armata* (Walcott)
Agraulos (?) capax Walcott, 1906	*Inouyia capax* (Walcott)
Agraulos divi Walcott, 1905	*Inouyia divi* (Walcott)
Agraulos (?) melie Walcott, 1906	*Inouyia melie* (Walcott)
Agraulos regularis Walcott, 1906	*Inouyia ? regularis* (Walcott)
Amphoton Lorenz, 1906	*Dolichometopus* Angelin
Amphoton steinmanni Lorenz, 1906	*Dolichometopus deois* Walcott
Anomocare bergioni Walcott, 1905	*Anomocarella bergioni* (Walcott)
Anomocare bianos Walcott, 1905	*Coosia ? bianos* (Walcott)
Anomocare bigsbyi Walcott, 1906	*Anomocarella bigsbyi* (Walcott)
Anomocare biston Walcott, 1905	*Anomocarella biston* (Walcott)
Anomocare ? butes Walcott, 1905	*Anomocarella butes* (Walcott)
Anomocare commune Lorenz, 1906	*Anomocarella chinensis* Walcott
Anomocare daunus Walcott, 1905	*Coosia ? daunus* (Walcott)
Anomocare decelus Walcott, 1905	*Coosia decelus* (Walcott)
Anomocare eriopia Walcott, 1906	*Ptychoparia (Emmrichella) eriopia* (Walcott)
Anomocare limbatum Angelin, 1854	*Coosia (?) limbata* (Angelin)
Anomocare speciosum Lorenz, 1906	*Anomocarella speciosa* (Lorenz)
Anomocare tatian Walcott, 1905	*Anomocarella tatian* (Walcott)
Anomocare temenus Lorenz, 1906	*Anomocarella temenus* (Walcott)
Anomocare temenus Walcott, 1905	*Anomocarella temenus* (Walcott)
Anomocarella ? bura Walcott, 1905	*Lisania bura* (Walcott)
Anomocarella carme Walcott, 1905	*Coosia carme* (Walcott)
Anomocarella contigua Walcott, 1906	*Anomocarella albion* (Walcott)
Arionellus agonius Walcott, 1905	*Lisania agonius* (Walcott)
Arionellus ajax Walcott, 1905	*Lisania ajax* (Walcott)
Arionellus alala Walcott, 1905	*Lisania alala* (Walcott)
Bathyuriscus asiaticus Lorenz, 1906	*Dolichometopus deois* Walcott
Bradoria bergeroni Walcott, 1905	*Aluta bergeroni* (Walcott)
Bradoria enyo Walcott, 1905	*Aluta enyo* (Walcott)
Bradoria eris Walcott, 1905	*Aluta eris* (Walcott)
Bradoria fragilis Walcott, 1905	*Aluta fragilis* (Walcott)
Bradoria sterope Walcott, 1905	*Aluta sterope* (Walcott)
Bradoria woodi Walcott, 1905	*Aluta woodi* (Walcott)
Calymmene ? sinensis Bergeron, 1899	*Blackwelderia sinensis* (Bergeron)
Conocephalites subquadratus Dames, 1883	*Anomocare subquadratum* (Dames)
Conocephalites typus Dames, 1883	*Ptychoparia typus* (Dames)
Craniella ?? sp. Walcott, 1905	*Discinopsis sulcatus* (Walcott)
Damesella Walcott, 1905	*Stephanocare* Monke
Damesella chione Walcott, 1905	*Stephanocare richthofeni* Monke
Damesella sinensis Walcott, 1905	*Stephanocare ? sinensis* (Bergeron)
Dicellocephalus ? sinensis Bergeron, 1899	*Stephanocare ? sinensis* (Bergeron)
Dikelocephalus ? baubo Walcott, 1905	*Ptychaspis baubo* (Walcott)
Dikelocephalus ? brizo Walcott, 1905	*Ptychaspis brizo* (Walcott)
Dorypygella Walcott, 1905	*Teinistion* Monke
Dorypygella alastor Walcott, 1905	*Blackwelderia alastor* (Walcott)
Dorypygella alcon Walcott, 1905	*Teinistion alcon* (Walcott)
Dorypygella typicalis Walcott, 1905	*Teinistion typicalis* (Walcott)
Hoeferia Redlich, 1901	*Redlichia* Cossman, 1902
Liostracus megalurus Dames, 1883	*Anomocare megalurus* (Dames)
Menocephalus adrastia Walcott, 1905	*Levisia adrastia* (Walcott)
Menocephalus belenus Walcott, 1905	*Lisania belenus* (Walcott)
Obolus (Lingulepis) eros Walcott, 1905	*Lingulella (Lingulepis) eros* (Walcott)

Former generic reference.	*Present generic reference.*
Obolus (*Lingulepis ?*) sp. undt. Walcott, 1906	*Lingulella* (*Lingulepis ?*) sp. undt. (Walcott)
Olenoides ? cilix Walcott, 1905	*Blackwelderia cilix* (Walcott)
Olenoides leblanci Bergeron, 1899	*Blackwelderia sinensis* (Bergeron)
Orthis linnarssoni Kayser, 1883	*Eoorthis linnarssoni* (Kayser)
Orthis (*Plectorthis*) *agreste* Walcott, 1906	*Eoorthis agreste* (Walcott)
Orthis (*Plectorthis*) *doris* Walcott, 1905	*Eoorthis doris* (Walcott)
Orthis (*Plectorthis*) *kayseri* Walcott, 1905	*Eoorthis kayseri* (Walcott)
Orthis (*Plectorthis*) *kichouensis* Walcott, 1906	*Eoorthis kichouensis* (Walcott)
Orthis (*Plectorthis*) *linnarssoni* Walcott, 1905	*Eoorthis linnarssoni* (Kayser)
Orthis (*Plectorthis*) *pagoda* Walcott, 1905	*Eoorthis pagoda* (Walcott)
Orthis (*Plectorthis*) sp. undt. Walcott, 1906	*Eoorthis* sp. undt. (Walcott)
Platyceras chronus Walcott, 1905	*Pelagiella chronus* (Walcott)
Platyceras clytia Walcott, 1905	*Pelagiella clytia* (Walcott)
Platyceras pagoda Walcott, 1905	*Pelagiella pagoda* (Walcott)
Platyceras willisi Walcott, 1906	*Pelagiella willisi* (Walcott)
Ptychoparia ? batia Walcott, 1905	*Chuangia batia* (Walcott)
Ptychoparia ? bromus Walcott, 1905	*Ptychoparia* (*Emmrichella*) *bromus* (Walcott)
Ptychoparia ceus Walcott, 1905	*Liostracina krausei* Monke
Ptychoparia granulosa Walcott, 1905	*Ptychoparia granosa* Walcott
Ptychoparia comus Walcott, 1906	*Anomocarella comus* (Walcott)
Ptychoparia constricta Walcott, 1905	*Ptychoparia* (*Emmrichella*) *constricta* (Walcott)
Ptychoparia dryope Walcott, 1905	*Conokephalina ? dryope* (Walcott)
Ptychoparia inflata Walcott, 1906	*Inouyia ? inflata* (Walcott)
Ptychoparia (*?*) *maia* Walcott, 1906	*Conokephalina maia* (Walcott)
Ptychoparia mantoensis Walcott, 1905	*Ptychoparia* (*Emmrichella*) *mantoensis* (Walcott)
Ptychoparia nereis Walcott, 1906	*Anomocare ? nereis* (Walcott)
Ptychoparia tellus Walcott, 1905	*Lonchocephalus tellus* (Walcott)
Ptychoparia tenes Walcott, 1905	*Anomocarella tenes* (Walcott)
Ptychoparia theano Walcott, 1905	*Ptychoparia* (*Emmrichella*) *theano* (Walcott)
Ptychoparia titiana Walcott, 1905	*Inouyia titiana* (Walcott)
Ptychoparia undata Walcott, 1906	*Anomocarella undata* (Walcott)
Ptychoparia vesta Walcott, 1906	*Conokephalina vesta* (Walcott)
Ptychoparia sp. undt. Walcott, 1906	*Conokephalina* sp. undt. (Walcott)
Ptychoparia (*Liostracus*) *intermedia* Walcott, 1906	*Solenopleura intermedia* (Walcott)
Ptychoparia (*Liostracus*) *megalurus* Walcott, 1905	*Anomocare megalurus* (Dames)
Ptychoparia (*Liostracus*) *subrugosa* Walcott, 1906	*Anomocarella subrugosa* (Walcott)
Ptychoparia (*Liostracus*) *thraso* Walcott, 1905	*Anomocarella thraso* (Walcott)
Ptychoparia (*Liostracus*) *toxeus* Walcott, 1905	*Anomocarella toxeus* (Walcott)
Ptychoparia (*Liostracus*) *trogus* Walcott, 1905	*Anomocarella trogus* (Walcott)
Ptychoparia (*Liostracus*) *tutia* Walcott, 1905	*Anomocarella tutia* (Walcott)
Ptychoparia (*Proampyx*) *burea* Walcott, 1905	*Proampyx burea* (Walcott)
Shantungia Lorenz, 1906	*Chuangia* Walcott
Shantungia Walcott, 1905	*Shantungia* Walcott
Shantungia buchruckeri Lorenz, 1906	*Chuangia nitida* Walcott
Solenopleura abderus Walcott, 1905	*Menocephalus abderus* (Walcott)
Solenopleura acantha Walcott, 1905	*Menocephalus acanthus* (Walcott)
Solenopleura acidalia Walcott, 1905	*Menocephalus acidalia* (Walcott)
Solenopleura belus Walcott, 1905	*Conokephalina belus* (Walcott)
Stenotheca clurius Walcott, 1905	*Helcionella clurius* (Walcott)
Stenotheca rugosa chinensis Walcott, 1905	*Helcionella rugosa chinensis* (Walcott)
Stenotheca rugosa orientalis Walcott, 1905	*Helcionella rugosa orientalis* (Walcott)
Stenotheca simplex Walcott, 1906	*Helcionella ?? simplex* (Walcott)
Stephanocare sinensis Monke, 1903	*Blackwelderia sinensis* (Bergeron)
Straparollina circe Walcott, 1905	*Matherella circe* (Walcott)
Syntrophia orientalis Walcott, 1905	*Huenella orientalis* (Walcott)

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LOCALITIES (WITH LISTS OF GENERA AND SPECIES AT EACH).

For convenience of reference and to avoid repetition, the following list of localities, with the genera and species found in each, is inserted. The lists published by Willis and Blackwelder [1907, vol. 1, Pt. I] are composite lists made up by writing the lists of fossils from several localities in one list in order to give the fauna that in their judgment occurs at some one stratigraphic horizon of the Cambrian. For the purposes of the future student who may wish to study the geographic distribution of the various subfaunas and to work out the limits of the formations containing them, the local lists are essential and give all known data concerning localities from which fossils described in this paper have been obtained. When not otherwise stated, the collections were made by Dr. Eliot Blackwelder.

Chinese Localities.

C1. Just below C2, same section; just above C4, same section; about 75 feet below C62, which occurs at a locality 3 miles east; about same horizon as C10, different section; about 150 feet below C12, same section.

Middle Cambrian: Lower shale member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 40 (part of the third list of fossils), and fig. 10 (bed 4), p. 38], 2 miles (3.2 km.) south of Yen-chuang, Sin-t'ai district, Shan-tung. (At the second "x" from left side of section given on page 38 of Blackwelder, 1907*a*, Research in China.)

Protospongia chloris
Obolus minimus
Obolus (Westonia) blackwelderi
Acrotreta pacifica
Acrotreta shantungensis ?
Pelagiella chronus
Hyolithes cybele
Agnostus chinensis
Dorypyge richthofeni
Inouyia divi
Lisania agonius
Anomocarella albion
Anomocarella chinensis
Dolichometopus alceste
Dolichometopus deois
Dolichometopus derceto

C2. Just above C1, same section; above C4, same section; about same horizon as C10, different section.

Middle Cambrian: Lower shale member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 40 (part of the third list of fossils), and fig. 10 (beds 4 and 5), p. 38], 2 miles (3.2 km.) south of Yen-chuang, Sin-t'ai district, Shan-tung. C2 contains specimens from the central portion of the lower shale member—from the second "x" from the left side of the figure on page 38 to but not including the fourth "x" from the left.

Protospongia chloris
Obolus (Westonia) blackwelderi
Acrotreta pacifica
Hyolithes cybele
Orthotheca cyrene dryas
Agnostus chinensis
Dorypyge bispinosa
Lonchocephalus tellus
Lisania agonius
Anomocare latelimbatum
Anomocarella albion
Anomocarella biston
Anomocarella chinensis
Coosia ? daunus
Dolichometopus deois
Dolichometopus derceto

C3. About 100 feet above the horizon of C60, different section; about 175 feet below the horizon of C8, different sections.

Lower Cambrian: Lower part of the Man-t'o shale formation [Blackwelder, 1907*a*, p. 28 (list of fossils at bottom of page), and fig. 8*a* (bed 20), p. 28], on the southeast slope of Hu-lu-shan, 2.5 miles (4 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung.

Billingsella richthofeni
Helcionella rugosa chinensis
Hyolithes delia
Redlichia nobilis
Ptychoparia (Emmrichella) constricta

CHINESE LOCALITIES—Continued.

C4. Just below C1, same section; same horizon as C57, different section.

Middle Cambrian: In limestone nodules at the base of the lower shale member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 40 (second list of fossils), and fig. 10 (bed 4), p. 38], 3 miles (4.8 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung. In the section on page 38 of Blackwelder, 1907*a*, this horizon is at the base of bed 4 about halfway between the first and second "x's" from the left side.

Protospongia chloris
Acrothele matthewi eryx
Acrotreta pacifica
Pelagiella chronus
Hyolithes cybele
Hyolithes ? (operculum)
Orthotheca delphus
Agnostus chinensis
Lisania alala
Anomocarella albion
Anomocarella chinensis
Dolichometopus alceste
Dolichometopus deois

C5. About 25 feet above C8, same section; about 40 feet below C63, same section.

Middle Cambrian: Lower limestone member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 39 (first list of fossils), and fig. 8*a* (bed 30), p. 29], 3.2 miles (5.1 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung. In the section on page 29 of Blackwelder, 1907*a*, this horizon is at the bed marked "30." On the figure this is placed as occurring below the line dividing the Man-t'o from the Kiu-lung, but on the basis of the fauna contained in it the limestone is referred to the base of the Kiu-lung. The text [p. 39] places the boundary between the Kiu-lung and the Man-t'o, 15 feet below C5.

Globigerina ? mantoensis
Micromitra (Iphidella) pannula ophirensis
Acrotreta pacifica
Inouyia divi
Anomocare sp.
Anomocarella butes
Dolichometopus ? sp.

C6. About 120 feet above C12, same section; about 20 feet below C61, same section.

Middle Cambrian: Thin platy limestone in the upper shale member of the Kiu-lung group just below the Ch'au-mi-tién limestone [Blackwelder, 1907*a*, pp. 37 and 41 (second list of fossils), and fig. 10 (bed 12), p. 38], 2.5 miles (4 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung.

Obolus (Westonia) blackwelderi
Dicellomus parvus
Acrothele ? minuta
Agnostus douvillei
Redlichia sp. undt.
Stephanocare ? monkei
Stephanocare richthofeni
Stephanocare ? sinensis
Stephanocare ? sp. undt.
Blackwelderia sinensis
Drepanura ketteleri
Drepanura premesnili
Ptychoparia (Emmrichella) bromus
Liostracina krausei
Shantungia spinifera

C7. Just above C9, same section; about same horizon as C52, different section; about 200 feet below C10, same section.

Middle Cambrian: Lower limestone member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 39 (last list of fossils), and fig. 8*a* (bed 33), p. 29], 2.2 miles (3.5 km.) southwest of Yen-chuang, Sin-ta'i district, Shan-tung. In the section on page 29 of Blackwelder, 1907*a*, this horizon is not starred, but occurs at about the middle of the lower of the two bands of oolitic limestone numbered "33."

Obolus damesi
Lingulella (Lingulepis) eros
Inouyia abaris
Inouyia titiana
Agraulos dolon
Anomocare subquadratum
Anomocarella subrugosa
Anomocarella thraso

C8. About 25 feet below C5, same section; about 275 feet above C60, same section; about 175 feet above the horizon of C3, different section.

Middle Cambrian: Brown sandstone and limestone nodules in brown micaceous shales near the top of the Man-t'o formation [Blackwelder, 1907*a*, fig. 8*a* (bed 27), p. 29], 3.4 miles (5.4 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung. This horizon is starred opposite bed "27" on the section on page 29 of Blackwelder, 1907*a*. This is below the line between the Kiu-lung and the Man-t'o, both as represented on page 29 and as given in the text at the top of page 39.

Two species, *Ptychoparia impar* var. and *Anomocare* sp. undt.

CHINESE LOCALITIES—Continued.

C9. Just below C7, same section; about 25 feet above C63, same section; about same horizon as C52, different section.

Middle Cambrian: Lower limestone member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 39 (third list of fossils), and fig. 8*a* (bed 33), p. 29], 3 miles (4.8 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung. In the section on page 29 of Blackwelder, 1907*a*, this horizon is not starred, but occurs at the base of the lower of the two bands of oolitic limestone numbered "33."

Micromitra (Paterina) labradorica orientalis — *Anomocare minus*
Inouyia abaris — *Coosia decelus*

C10. About 200 feet above C7, same section; about same horizon as C1, C2, and C4, different section.

Middle Cambrian: Lower shale member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 40 (part of the third list of fossils), and fig. 8*a* (bed 35), p. 29], about 3 miles (4.8 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung.

Obolus damesi — *Menocephalus* sp. undt — *Anomocarella temenus*

C11. About same horizon as C61, different section; above C57, same section; about same horizon as C33*a*, different section.

Upper Cambrian: Crystalline limestone 60 feet (18 m.) above the base of the uppermost limestone member [Blackwelder, 1907*a*, pp. 37 and 41 (last list of fossils)] 2.1 miles (3.4 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung.

Two species, *Chuangia batia* and *Chuangia nitida*.

C12. About 120 feet below C6, same section; about 75 feet above C62, same section but at a locality 3 miles east; C13 includes the horizon represented by C12; about 150 feet above C1, same section.

Middle Cambrian: Gray limestone near the top of the middle limestone member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 41 (part of the first list of fossils), and fig. 10 (bed 7), p. 38], 3.25 miles (5.2 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung. This horizon is starred at the top of bed "7" in the section on page 28.

Acrotreta pacifica	*Blackwelderia alastor*	*Inouyia acalle*
Teinistion alcon	*Damesella blackwelderi*	*Lisania ajax*
Teinistion typicalis	*Pterocephalus asiaticus*	*Anomocarella tutia*

C13. The horizon of C13 includes that of C12; about 120 feet below C6, same section; about 75 feet above C62, which is in same section but at a locality 3 miles east; about 150 feet above C1, same section.

Middle Cambrian: Yellow slabby limestone in the middle limestone member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 41, part of the first list of fossils], on the west slope of hill in angle between two faults, just east of the granite mass of the Lién-hua-shan, 6 miles (9.6 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung. Collected at some distance from C12 and includes more. Its horizon is that of bed 7 of fig. 10, page 38.

Two species, *Damesella bella granulata* and *Damesella blackwelderi*.

C14. From the horizons of C12 and C13.

Middle Cambrian: In talus from the middle limestone member of the Kiu-lung group [Blackwelder, 1907*a*, p. 37], 2.8 miles (4.5 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung. Field label says section 6K, stratum 11, which is about 200 feet above C61. Note by C. D. Walcott says it is from stratum 4, the horizon of C12 and C13.

One species, *Damesella blackwelderi*.

C15. About same horizon as C16 and C27.

Lower Cambrian: Slaty black limestone in the lower part of the Man-t'o shale [Blackwelder, 1907*a*, p. 26, third paragraph; and fig. 6 (bed 7), p. 25], at Ch'ang-hia, Shan-tung.

One species, *Redlichia chinensis*.

CHINESE LOCALITIES—Continued.

C16. About same horizon as C15 and C27.
Lower Cambrian: Slaty black limestone in the lower part of the Man-t'o shale [Blackwelder, 1907*a*, p. 26, third paragraph; and fig. 6 (bed 7), p. 25], 2 miles (3.2 km.) south of Ch'ang-hia, Shan-tung.
Two species, *Redlichia chinensis* and *Redlichia* sp. undt.

C17. About 180 feet below C23, same section; about 35 feet above C20, adjacent sections; about 160 feet below C 28, adjacent sections.
Lower Cambrian: Ferruginous limestone nodules in the brown sandy shales at the top of the Man-t'o shale [Blackwelder, 1907*a*, p. 27 (list of fossils at top of page), and fig. 6 (bed 15), p. 25], at Ch'ang-hia, Shan-tung.

Obolella asiatica *Ptychoparia aclis* *Ptychoparia granosa* *Ptychoparia impar*

C18. Below horizon of C19, C22, C24, and C26, same section; above C21, same section.
Middle Cambrian: Dark gray oolitic limestone about 400 feet (120 m.) above the base of the Ch'ang-hia limestone [Blackwelder, 1907*a*, p. 33 (third list of fossils)], in cliffs 1 mile (1.6 km.) east of Ch'ang-hia, Shan-tung.

Scenella clotho *Helcionella rugosa orientalis* *Crepicephalus magnus*
Pelagiella chronus *Crepicephalus damia* *Menocephalus acerius*

C19. About same horizon as C22, C24, and C26, same section; about same horizon as C25, different section.
Middle Cambrian: Uppermost layers of the Ch'ang-hia limestone [Blackwelder, 1907*a*, p. 33, part of the last list of fossils], at Ch'ang-hia, Shan-tung.

Dorypyge richthofeni *Menocephalus abderus* *Anomocarella tutia*
Damesella brevicaudata *Anomocare daulis* *Dolichometopus deois*
Lisania belenus

C20. About 15 feet above C31, same section; about 35 feet below C17, different section.
Lower Cambrian: Central part of the Man-t'o shale formation [Blackwelder, 1907*a*, p. 26 (last list of fossils) and fig. 6 (bed 14), p. 25], on the west side of an isolated butte 1 mile (1.6 km.) south of Ch'ang-hia, Shan-tung.

Billingsella richthofeni *Ptychoparia aclis* *Ptychoparia (Emmrichella) mantoensis*

C21. About 100 feet above C30, different sections; about 100 feet below C18, same section.
Middle Cambrian: Ocher-mottled phase of purple-gray limestone in the middle of the oolitic Ch'ang-hia formation [Blackwelder, 1907*a*, p. 33 (second list of fossils)], at Ch'ang-hia, Shan-tung.

Helcionella rugosa orientalis *Crepicephalus damia* *Solenopleura* sp. undt.

C22. About same horizon as C19, C24, and C26, same section; above C18, same section.
Middle Cambrian: Ch'ang-hia limestone in upper oolitic portion [Blackwelder, 1907*a*, pp. 22 and 33 (part of the last list of fossils)], at Ch'ang-hia, Shan-tung.

Acrotreta lisani *Lisania bura* *Menocephalus admeta*
Hyolithes cybele *Menocephalus acantha* *Anomocarella temenus*
Lisania alala

C23. About 180 feet above C17, same section; about 25 feet above C28, different section.
Middle Cambrian: Upper part of thin-bedded gray oolitic limestone at the base of the Ch'ang-hia formation [Blackwelder, 1907*a*, p. 32 (second list of fossils), and fig. 6 (bed 20), p. 25], 50 feet (15 m.) below the base of the cliffs 1 mile (1.6 km.) east-southeast of Ch'ang-hia, Shan-tung. This horizon is the fourth bed above the black line in the figure on page 25, the one opposite bed "20."

Acrothele rara *Ptychoparia (Emmrichella) eriopia* *Agraulos abrota*
Orthotheca daulis *Ptychoparia (Emmrichella) theano* *Anomocarella tatian*

CHINESE LOCALITIES—Continued.

C24. About same horizon as C19, C22, and C26, same section; above C18, same section; about same horizon as C25, different section.

Middle Cambrian: Near top of black oolite group in the uppermost layers of the Ch'ang-hia formation [Blackwelder, 1907*a*, p. 33, part of the last list of fossils], 2 miles (3.2 km.) east of Ch'ang-hia, Shan-tung.

Acrotreta cf. *pacifica* — *Agnostus* sp. undt. (pygidium) — *Dolichometopus dirce*
Dorypyge richthofeni — *Inouyia divi*

C25. About same horizon as C19, C22, C24, and C26, different section; above C35, same section.

Middle Cambrian: Limestone about 50 feet (15 m.) below the Ku-shan shale in the uppermost beds of the Ch'ang-hia formation [Blackwelder, 1907*a*, p. 33, part of the last list of fossils], at Ch'ang-hia, Shan-tung.

Crepicephalus cf. *magnus* — *Levisia agenor* — *Anomocarella trogus*
Solenopleura agno — *Anomocare* sp.

C26. About same horizon as C19, C22, and C24, same section; about same horizon as C25, different section; above C18, same section.

Middle Cambrian: Near the top of the black oolite group in the uppermost layers of the Ch'ang-hia limestone [Blackwelder, 1907*a*, p. 33, part of the last list of fossils], 2 miles (3.2 km.) north-northeast of Ch'ang-hia, Shan-tung.

Eoorthis sp. undt. — *Crepicephalus damia* — *Anomocare ? daulis*

C27. About same horizon as C15 and C16.

Lower Cambrian: Buff and drab shales in the lower part of the Man-t'o shale [Blackwelder, 1907*a*, p. 26, third paragraph; and fig. 6 (bed 7), p. 25], on crest of ridge at Ch'ang-hia, Shan-tung.

Two species: *Redlichia chinensis* and *Redlichia* sp.

C28. About 200 feet above C20, same section; about 160 feet above C17, adjacent section; about 25 feet below C23, different section.

Middle Cambrian: Thin-bedded oolitic limestone at the base of the Ch'ang-hia limestone [Blackwelder, 1907*a*, p. 32 (first list of fossils), and fig. 6 (bed 20), p. 25], just above the shales in the face of the cliff 1 mile (1.6 km.) east-southeast of Ch'ang-hia, Shan-tung. This horizon is the first layer in bed "20" (see figure on p. 25) above the black line.

Eoorthis agreste — *Anomocarella tenes* — *Bathyuriscus ?* sp.
Inouyia thisbe — *Anomocarella toxeus*

C29. Below C30, same section; about same horizon as C48, different section.

Middle Cambrian: Near the top of the cliffy limestone in the Ch'ang-hia limestone [Blackwelder, 1907*a*, p. 32, part of the last list of fossils], 1 mile (1.6 km.) west of Ch'ang-hia, Shan-tung.

Two species: *Dorypyge richthofeni* and *Agraulos dryas*.

C30. About 100 feet below C21, different section; above C29, same section; below C35, same section; about same horizon as C51, different section.

Middle Cambrian: Layer in black oolite of Ch'ang-hia limestone [Blackwelder, 1907*a*, p. 33, part of the first list of fossils], 25 feet (7.5 m.) above the second cliff at an elevation of 1,700 feet (568.9 m.) on top of the long north and south ridge at Ch'ang-hia, Shan-tung.

Dorypyge richthofeni — *Anomocare* sp. — *Menocephalus agave*
Lisania alala — *Menocephalus acidalia* — *Levisia adrastia*
Lisania sp. undt.

C31. About 15 feet below C20, same section.

Lower Cambrian: Gray crystalline limestone in the central portion of the Man-t'o shale [Blackwelder, 1907*a*, p. 26 (first list of fossils), and fig. 6 (bed 12), p. 25], at Ch'ang-hia, Shan-tung.

Ptychoparia aclis — *Ptychoparia ligea* — *Ptychoparia* (*Emmrichella*) *mantoensis*

CHINESE LOCALITIES—Continued.

C32. See also C32′, other drift blocks at the same locality.
Middle Cambrian: A fine-grained bluish-black limestone bowlder believed to have come from the lower part of the Ki-sin-ling limestone [Blackwelder, 1907*b*, p. 272], collected in river drift 1 mile (1.6 km.) south of Chön-p'ing-hién, on the Nan-kiang River, southern Shen-si.

Obolus shansiensis	*Orthotheca doris*	*Aluta enyo*	*Aluta sterope*
Dicellomus parvus	*Microdiscus orientalis*	*Aluta eris*	*Aluta woodi*
Acrotreta shantungensis	*Aluta bergeroni*	*Aluta fragilis*	

C32′. See C32, another drift block at the same locality.
Lower Cambrian: A limestone bowlder collected in river drift 1 mile (1.6 km.) south of Chön-p'ing-hién, on the Nan-kiang River, southern Shen-si.
Two species: *Obolella asiatica* and *Hyolithes* sp. undt.

C33. *Upper Cambrian:* About 100 feet (30 m.) above the base of the Ch'au-mi-tién limestone, 9 miles (14.4 km.) north of Sin-t'ai-hién, Shan-tung.
One species, *Ptychaspis* sp. (free cheeks and fragments).

C33*a*. About same horizon as C11, different section.
Upper Cambrian: Talus near the base of the cliff of Ch'au-mi-tién limestone [Blackwelder, 1907*a*, p. 41, part of the last list of fossils], 9 miles (14.4 km.) north of Sin-t'ai-hién, Shan-tung.
Two species: *Chuangia batia* and *Anomocarella bergioni.*

C34. About same horizon as C38, C41, and C49, different sections.
Upper Cambrian: Purplish-gray limestone about 100 feet (30 m.) above the base of the Ch'au-mi-tién formation [Blackwelder, 1907*a*, p. 36, part of the first list of fossils] in road at northeastern corner of small village near Ch'au-mi-tién, Ch'ang-hia district, Shan-tung.

Pagodia macedo	*Agnostus* sp. undt.	*Ptychaspis ceto*	*Illænurus canens*

C35. Below C25, same section.
Middle Cambrian: Upper part of the Ch'ang-hia limestone [Blackwelder, 1907*a*, p. 33, fifth paragraph], at Ch'au-mi-tién, Ch'ang-hia district, Shan-tung.
One species, *Menocephalus acis.*

C36. About same horizon as C45, different section; about same horizon as C50, same section; above C68, same section; about same horizon as C47, same section.
Upper Cambrian: Upper part of the Ch'au-mi-tién limestone [Blackwelder, 1907*a*, p. 36 (part of the third list of fossils), and fig. 9 (bed 2), p. 35], at Ch'au-mi-tién, Ch'ang-hia district, Shan-tung.
Two species: *Billingsella pumpellyi* and *Anomocarella baucis.*

C37. About same horizon as C72, same section; about 50 feet above C71, same section; about 200 feet below C73, same section; about 225 feet below C74, same section.
Middle Cambrian: Upper part of the Ki-chóu limestone,[1] in dense black limestone nodules in green-gray shales 10 feet (3 m.) below the base of the cliff limestone, 8 miles (12.8 km.) south of Ting-hiang-hién, Shan-si.

Obolus shansiensis	*Acrotreta shantungensis*	*Anomocare megalurus*

C38. About same horizon as C34, C41, and C49, different sections; below C43, same section.
Upper Cambrian: Crystalline limestone near the base of the Ch'au-mi-tién limestone [Blackwelder, 1907*a*, p. 36, part of the first list of fossils], at Ch'au-mi-tién, Ch'ang-hia district, Shan-tung.

Coosia carme	*Ptychaspis ceto*	*Illænurus canens*
Ptychaspis brizo	*Hysterolenus* sp.	*Illænurus ceres*

[1]The fossils from this locality are not listed, but the presence of Cambrian strata at the locality is mentioned by Willis and Blackwelder [1907, p. 146].

CHINESE LOCALITIES—Continued.

C39 = *Ordovician.*

C40. About same horizon as C12, C13, and C14, same section.
Middle Cambrian: Limestone nodules in green shales in the middle limestone member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 41 (part of the first list of fossils)], in a gully in bank of river 2 miles (3.2 km.) south of Yen-chuang, Sin-t'ai district, Shan-tung.
Two species: *Damesella blackwelderi* and *Lisania ajax.*

C41. Same horizon as C49, C54, and C56, same section; about same horizon as C34 and C38, different section.
Upper Cambrian: Lower part of the Ch'au-mi-tién limestone [Blackwelder, 1907*a*, p. 36, part of the first list of fossils], 2.7 miles (4.3 km.) southwest of Ch'au-mi-tién, Ch'ang-hia district, Shan-tung.

Lisania sp. undt. — *Ptychaspis cadmus* — *Illænurus canens*
Pagodia dolon — *Ptychaspis calchas*

C42. *Upper Cambrian:* In the central part of the Ch'au-mi-tién limestone [Blackwelder, 1907*a*, p. 36, second list of fossils], 1.8 miles (2.9 km.) west-southwest from the temple on Tsing-lung-shan, 7.5 miles (12 km.) east of Ch'au-mi-tién, Ch'ang-hia district, Shan-tung.

Ptychaspis calyce — *Ptychaspis campe* — *Illænurus canens*

C43. Above C38, same section.
Upper Cambrian: Near the top of crystalline, mostly purple-gray limestone in the Ch'au-mi-tién limestone, at Ch'au-mi-tién, Ch'ang-hia district, Shan-tung.
No identifiable species.

C44. *Upper Cambrian:* In talus 200 feet (60 m.) above the top of the section containing C46, C48, and C51, at Ch'au-mi-tién, Ch'ang-hai district, Shan-tung.
One species, *Chuangia batia.*

C45. Same horizon as C36 and C68, different section; about 900 feet (270 m.) above C25, same section; supposed to be from same horizon as C50 and C67.
Upper Cambrian: Limestone about 40 feet (12 m.) below the top of the Ch'au-mi-tién limestone [Blackwelder, 1907*a*, p. 36 (part of third list of fossils)], at Ch'au-mi-tién, Ch'ang-hia district, Shan-tung.

Ptychaspis acamus — *Ptychaspis ceto* — *Illænurus* sp. undt.

C46. Above C51, same section; about same horizon as C75, different section.
Middle Cambrian: Light gray crystalline limestone in the Ch'ang-hia limestone [Blackwelder, 1907*a*, p. 33, fourth list of fossils], at Ch'au-mi-tién, Ch'ang-hia district, Shan-tung.

Helcionella ? clurius — *Anomocare* sp. (free cheek and pygidium) — *Damesella* sp. (free cheek)
Lisania alala — *Damesella ?* sp. (free cheek)

C47. About same horizon as C36, same section.
Upper Cambrian: Upper part of the Ch'au-mi-tién limestone [Blackwelder, 1907*a*, fig. 9 (top of bed 1), p. 35], at the top of a high col at Ch'au-mi-tién, Ch'ang-hia district, Shan-tung.

Pelagiella clytia — *Orthotheca cyrene* — *Ptychaspis* sp.

C48. Below C51, same section; about same horizon as C29, different section.
Middle Cambrian: Near the top of the cliffy oolitic limestone in the Ch'ang-hia limestone [Blackwelder, 1907*a*, p. 32, part of the last list of fossils], at Ch'au-mi-tién, Ch'ang-hia district, Shan-tung.
Two species, *Ptychoparia* sp. undt. and *Crepicephalus magnus.*

CHINESE LOCALITIES—Continued.

C49. Same horizon as C41, C54, and C56, same section; about same horizon as C34 and C38, different sections.

Upper Cambrian: Purplish-brown limestone in the lower part of the Ch'au-mi-tién limestone [Blackwelder, 1907*a*, p. 36, part of the first list of fossils], in roadway 2.5 miles (4 km.) west-southwest of Ch'au-mi-tién, Ch'ang-hia district, Shan-tung.

One species, *Menocephalus ? depressus.*

C50. About same horizon as C36, C47, and C68, same section; supposed to be from horizon of C45 and C67.

Upper Cambrian: Upper part of the Ch'au-mi-tién limestone [Blackwelder, 1907*a*, p. 36 (part of the third list of fossils)], on a low spur at Ch'au-mi-tién, Ch'ang-hia district, Shan-tung.

One species, *Ptychaspis* sp.

C51. Below C46, same section; above C48, same section; about same horizon as C30, different section.

Middle Cambrian: Lower part of gray crystalline limestone in the upper portion of the oolitic part of the Ch'ang-hia limestone [Blackwelder, 1907*a*, p. 33, part of the first list of fossils], at Ch'au-mi-tién, Ch'ang-hia district, Shan-tung.

Shumardia sp.
Lisania alala
Solenopleura agno
Solenopleura intermedia

C52. *Middle Cambrian:* In the lower part of the lower limestone member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 39 (second list of fossils), and fig. 7 (bed 22), p. 27], near base of cliffs in mountain 1,000 feet (305 m.) high, 3 miles (4.8 km.) north-northeast of Sin-t'ai-hién, Shan-tung.

Ptychoparia tolus
Agraulos dirce
Anomocare latelimbatum
Anomocarella butes

C53. = *Ordovician.*

C54. Same horizon as C41, C49, and C56; about same horizon as C34 and C38, different sections.

Upper Cambrian: Lower part of Ch'au-mi-tién limestone [Blackwelder, 1907*a*, p. 42, (part of the last list of fossils)], near top of limestone knoll two-thirds of a mile (1.1 km.) west of Tsi-nan, Shan-tung.

Obolus matinalis ?
Eoorthis pagoda
Syntrophia orthia
Pterocephalus busiris
Ptychaspis ceto
Ptychaspis sp. undt. (free cheek)
Illænurus canens
Illænurus sp. undt. (pygidium)

C55. (See C6.)

Middle Cambrian: Thin platy limestone in the upper shale member of the Kiu-lung group just below the Ch'au-mi-tién limestone [Blackwelder, 1907*a*, p. 43], in isolated hills at an elevation of 380 feet (114 m.) above the Wön-ho, 12 miles (19 km.) south, 80° east of Tsi-nan, Shan-tung.

Straparollina sp. undt.
Agnostus douvilléi
Stephanocare richthofeni
Blackwelderia cilix
Drepanura ketteleri
Drepanura premesnili

C56. Same horizons as C41, C49, and C54.

Upper Cambrian: Lower part of Ch'au-mi-tién limestone, 25 feet (7 5 m.) below the top of Pagoda Hill [Blackwelder, 1907*a*, p. 42 (part of the last list of fossils)], 1 mile (1.6 km.) west of Tsi-nan, Shan-tung.

Obolus (*Westonia*) sp. undt.
Discinopsis sulcatus
Eoorthis pagoda
Syntrophia orthia
Scenella sp. undt.
Matherella circe
Pelagiella pagoda
Orthotheca sp. undt.
Cyrtoceras cambria
Conokephalina belus
Conokephalina dryope
Pagodia bia
Pagodia lotos
Menocephalus ? depressus
Ptychaspis ceto
Hysterolenus ? (pygidium)
Illænurus dictys

CHINESE LOCALITIES—Continued.

C57. Same horizon as C4, different section; below C11, same section; above C58, same section.

Middle Cambrian: In limestone nodules in the lower shale member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 40 (first list of fossils)], 3 miles (4.8 km.) south of Kao-kia-p'u, and 4 miles (6.4 km.) north of Sin-t'ai-hién, Sin-t'ai district, Shan-tung.

Acrothele rara	*Agnostus kushanensis*	*Anomocarella albion*
Orthotheca delphus	*Dorypyge richthofeni*	*Anomocarella chinensis*
Agnostus chinensis	*Anomocare alcinoe*	*Dolichometopus deois*

C58. Below C57, same section.

Middle Cambrian: Green shale near the middle of the Ch'ang-hia limestone, at top of hill 2 miles (3.2 km.) south-southeast of Kao-kia-p'u, Shan-tung.

Two species, *Redlichia finalis* and *Ptychoparia ?* sp. (pygidium).

C59. = *Ordovician* and *Carboniferous.*

C60. About 100 feet below the horizon of C3, different section; about 250 feet below C8, same section.

Lower Cambrian: Slaty black limestones in the lower part of the Man-t'o shales [Blackwelder, 1907*a*, p. 28 (third paragraph), and fig. 8 (bed 11), p. 28], 3.5 miles (5.6 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung.

One species, *Redlichia* sp.

C61. About 25 feet above C6, same section; about 125 feet below C64, same section; about same horizon as C11, different section.

Upper Cambrian: A dense black limestone in the uppermost limestone member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 41 (third list of fossils), and fig. 10 (bed 13), p. 38], 3 miles (4.8 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung. This horizon is at the lower of the two stars opposite bed "13" on page 38.

Billingsella pumpellyi	*Pterocephalus busiris*	*Chuangia fragmenta*
Proampyx burea	*Chuangia batia*	*Ptychaspis baubo*

C62. About 75 feet above C1, which occurs at a locality 3 miles east; about 75 feet below C12 and C13, same section.

Middle Cambrian: Earthy layer in the middle limestone of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 40 (last list of fossils, and fig. 10 (base of bed 7), p. 38], 2.5 miles (4 km.) south of Yen-chuang, on the north-northeast spur of Hu-lu-shan, Sin-t'ai district, Shan-tung.

Obolus chinensis	*Hyolithes cybele*
Acrotreta shantungensis	*Anomocarella chinensis*

C63. About 40 feet above C5, same section; about 25 feet below C9, same section.

Middle Cambrian: Sandy shale near the base of the Kiu-lung group [Blackwelder, 1907*a*, p. 37 (third paragraph), and fig. 8*a* (bed 32), p. 29], 3.5 miles (5.6 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung.

One species, *Obolus obscurus.*

C64. About 125 feet above C61, same section.

Upper Cambrian: Upper limestone member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 42 (first list of fossils), and fig. 10 (bed 20), p. 38], 2.7 miles (4.3 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung.

Obolus damesi	*Syntrophia orthia*	*Chuangia nais*	*Ptychaspis ceto*
Eoorthis doris	*Hyolithes daphnis*	*Ptychaspis baubo*	*Ptychaspis* sp. undt.
Eoorthis kayseri	*Orthotheca cyrene*	*Ptychaspis cacus*	(free cheek)
Eoorthis linnarssoni	*Solenopleura beroe*	*Ptychaspis callisto*	*Anomocare* sp.
Huenella orientalis	*Chuangia batia*	*Ptychaspis calyce*	*Coosia ? bianos*

CHINESE LOCALITIES—Continued.

C65 = *Ordovician.*

C66. "Material probably lost." [Bailey Willis.]

C67. Supposed to be from horizon of C36, C45, C47, C50, and C68.

Upper Cambrian: Stream gravels (from the wash from the mountains south of the city) used in making the railroad grade one-third mile (0.5 km.) west of the west city gate at Tsi-nan, Shan-tung.

Obolus cf. *matinalis* *Eoorthis* cf. *linnarssoni* *Ptychaspis* sp. undt.

C68. Same horizon as C47 and C50, same section; about same horizon as C45, different section; below C36, same section.

Upper Cambrian: Upper part of the Ch'au-mi-tién limestone [Blackwelder, 1907*a*, p. 36 (part of the third list of fossils)], on crest of ridge east of Ch'au-mi-tién, 200 yards (183 m.) north of the wayside shrine, Ch'ang-hia district, Shan-tung.

Two species, *Eoorthis kayseri* and *Anomocarella ?* sp. undt.

C69. 35 feet above C70, same section; below C71, same section.

Middle Cambrian: Limestone in shales about 65 feet (19.5 m.) above the base of the Ki-chóu limestone [Willis and Blackwelder, 1907, p. 145. first list of fossils], 4 miles (6.4 km.) east of Fang-lan-chön, Shan-si.

Conokephalina vesta *Agraulos obscura* *Dolichometopus hyrie*
Inouyia inflata *Anomocare ? nereis*

C70. 35 feet below C69, same section.

Middle Cambrian: Oolitic limestone about 30 feet (9 m.) above the base of the Ki-chóu limestone [Willis and Blackwelder, 1907, p. 144, last list of fossils], 4 miles (6.4 km.) south-southwest of Tung-yü, Shan-si.

Scenella ? dilatatus *Conokephalina* sp. *Inouyia melie*
Helcionella ?? simplex *Inouyia capax* *Agraulos vicina*
Conokephalina maia

C71. About 50 feet below the horizon of C37 and C72, same section; about 125 feet above C75, different section.

Middle Cambrian: Massive cliff-making limestone in the central portion of the Ki-chóu formation [Willis and Blackwelder, 1907, pp. 139 and 145 (second list of fossils)], 4 miles (6.4 km.) southwest of Tung-yü, Shan-si.

Obolus shansiensis ? *Orthotheca glabra* *Solenopleura pauperata*
Yorkia ? orientalis *Agnostus chinensis* *Anomocarella bigsbyi*
Acrotreta shantungensis *Dorypyge richthofeni lævis* *Anomocarella comus*
Eoorthis sp. undt. *Crepicephalus damia* *Anomocarella undata*

C72. About same horizon as C37, same section; about 50 feet above C71, same section; about 200 feet below C73, same section; about 225 feet below C74, same section.

Middle Cambrian: Thin green-gray limestone interbedded with ocherous and green clay shales, overlying the massive oolite in the Ki-chóu formation [Willis and Blackwelder, 1907, pp. 139 and 145 (third list of fossils)], 4 miles (6.4 km.) east of Fang-lan-chön, Shan-si.

Lingulella (*Lingulepis ?*) sp. undt. *Dorypyge richthofeni lævis* *Anomocare flava*
Pelagiella willisi *Conokephalina* sp. undt. *Anomocare ? nereis*
Orthotheca glabra

C73. About 200 feet above C37 and C72, same section; about 25 feet below C74, same section.

Middle Cambrian: Conglomeritic limestones near the top of the Ki-chóu formation [Willis and Blackwelder, 1907, p. 145, fourth list of fossils], 4 miles (6.4 km.) east of Fang-lan-chön, Shan-si.

Two species, *Blackwelderia cilix* and *Inouyia ? regularis.*

CHINESE LOCALITIES—Continued.

C74. About 225 feet above the horizon of C37 and C72, same section; about 25 feet above C73, same section.

Upper Cambrian: A dense blue dolomitic limestone at the top of the Ki-chóu limestone [Willis and Blackwelder, 1907, pp. 139 and 145 (fifth list of fossils)], 4 miles (6.4 km.) east of Fang-lan-chön, Shan-si.

Two species, *Eoorthis kayseri* and *Ptychaspis bella.*

C75. About 125 feet below C71, different section.

Middle Cambrian: Limestone near the base of the Ki-chóu formation [Willis and Blackwelder, 1907, p. 143], 4.5 miles (7.2 km.) south of Wu-t'ai-hién, Shan-si.

Coscinocyathus elvira — *Eoorthis kichouensis* — *Inouyia armata* — *Agraulos nitida*
Obolus obscurus — *Ptychoparia lilia* — *Inouyia melie* — *Agraulos uta*

C76. (Indeterminate fragments only.)

C77. *Middle Cambrian:* Limestone interbedded in green shales not more than 300 feet (90 m.) above the Man-t'o shales [Willis and Blackwelder, 1907, p. 144, first list of fossils], 4 miles (6.4 km.) southeast of Yau-t'o, near Wu-t'ai-hién, Shan-si.

Lisania cf. *bura* — *Anomocare* sp. undt. — *Anomocarella irma*

MANCHURIAN LOCALITIES.

All of the collections from Manchuria came from Tschang-hsing-tau Island, east of Niang-niang-kung, in the southwestern section of the Province of Liau-tung. The general stratigraphic relations of the section are given by Blackwelder [1907, p. 92] and the detailed section of Iddings on page 46 of this memoir.

The collections were made by Prof. Joseph P. Iddings and his Chinese interpreter Li San, in September 1909.

35n. *Middle Cambrian: Fu-chóu series.* Limestones near the base of the series just above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general section showing stratigraphic relations]; collected in a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria. [Field locality No. 4; 1=36*c*, 2=35*r*, 4=35*n*, 5=36*d*, and 6=36*e*, are stated by Mr. Iddings to be very nearly the same horizon and at the same locality. They are the lowest fossils found.]

Protospongia chloris
Protospongia sp. undt.
Micromitra sculptilis
Micromitra (Paterina) lucina
Micromitra (Iphidella) pannula maladensis
Micromitra (Iphidella) pannula ophirensis
Obolus chinensis
Obolus damesi
Acrothele matthewi eryx
Acrotreta shantungensis
Hyolithes cybele
Orthotheca cyrene
Orthotheca delphus
Orthotheca glabra
Agnostus chinensis
Dorypyge richthofeni
Ptychoparia kochibei
Pterocephalus liches
Agraulos sorge
Solenopleura beroe
Solenopleura sp. undt.
Anomocare ephori
Anomocare latelimbatum
Anomocare megalurus
Anomocare minus
Anomocare minus var.
Anomocare subquadratum
Anomocarella chinensis
Anomocarella hermias
Anomocarella macar
Anomocarella temenus
Anomocarella cf. *temenus*

MANCHURIAN LOCALITIES—Continued.

35o. About 50 feet higher than 35*p*; about same horizon as 36*h*; see 36*g*.

Middle Cambrian: Fu-chóu series. Shales about 130 feet (40 m.) above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general section showing stratigraphic relations]; collected in drainage cuts a short distance back from the bluff (see 35*n*) forming the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria.

Obolus damesi
Acrothele matthewi eryx
Acrotreta shantungensis
Agnostus chinensis
Damesella sp. undt.
Ptychoparia typus
Dolichemotopus deois
Bathyuriscus manchuriensis

35p. About 80 feet above 35*n*; about 50 feet below 36*h*.

Middle Cambrian: Fu-chóu series. Shales about 80 feet (24 m.) above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general section showing stratigraphic relations]; collected in a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria.

Lingulella manchuriensis
Acrotreta pacifica
Agnostus chinensis
Dorypyge richthofeni
Dolichometopus deois

35q. About 70 feet higher than 36*h*; about 800 feet below 36*f*.

Middle Cambrian: Fu-chóu series. About 200 feet (61 m.) above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general stratigraphic relations]; collected in a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria.

Protospongia chloris
Lingulella marcia
Acrotreta venia
Damesella blackwelderi
Anomocare lisani

35r. Very nearly same horizon as 35*n*.

Middle Cambrian: Fu-chóu series. Limestones near the base of the series just above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general section showing stratigraphic relations]; collected in a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria.

Micromitra sculptilis
Micromitra (Paterina) lucina
Micromitra (Iphidella) pannula maladensis
Obolus damesi
Obolus shansiensis
Acrothele matthewi eryx
Acrotreta shantungensis
Hyolithes cybele
Orthotheca delphus
Agnostus chinensis
Dorypyge richthofeni
Ptychoparia kochibei
Crepicephalus convexus
Solenopleura agno
Solenopleura chalcon
Anomocare ephori
Anomocarella chinensis
Anomocarella temenus
Dolichemotopus deois
Asaphiscus iddingsi

36c. Very nearly same horizon as 35*n*.

Middle Cambrian: Fu-chóu series. Limestones near the base of the series just above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general section showing stratigraphic relations]; collected in a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria.

No identifiable species.

36d. Very nearly same horizon as 35*n*.

Middle Cambrian: Fu-chóu series. Shales near the base of the series just above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general section showing stratigraphic relations]; collected in a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria.

Micromitra (Paterina) lucina
Obolus damesi
Acrothele matthewi eryx

MANCHURIAN LOCALITIES—Continued.

36e. Very nearly same horizon as 35*n*.

Middle Cambrian: Fu-chóu series. Shales interbedded with limestones near the base of the series just above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general section showing stratigraphic relations]; collected in a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria.

Obolus damesi
Acrothele matthewi eryx
Agnostus chinensis
Ptychoparia kochibei
Anomocare minus
Anomocare minus var.
Asaphiscus iddingsi

36f. About 800 feet above 35*q*; the highest horizon.

Middle Cambrian: Fu-chóu series. About 1,000 feet (305 m.) above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general stratigraphic relations]; collected in a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria.

Planolites (annelid trails)
Lingulella marcia ?
Agnostus douvilléi
Albertella pacifica
Teiniston typicalis
Stephanocare sinensis
Blackwelderia sinensis
Damesella blackwelderi
Drepanura premesnili
Liostracina krausei
Shantungia spinifera

36g. About 50 feet higher than 35*p*; about same horizon as 36*h*; see 35*o*.

Middle Cambrian: Fu-chóu series. Shale about 130 feet (40 m.) above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general section showing stratigraphic relations]; collected in drainage cuts a short distance back from the bluff (see 35*n*) forming the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria.

Obolus damesi
Acrothele matthewi eryx
Acrotreta shantungensis
Orthotheca cf. *delphus*
Agnostus chinensis
Anomocarella chinensis
Bathyuriscus manchuriensis

36h. About 70 feet below 35*q*; about 50 feet above 35*p*; 36*g* and 35*o* are from approximately the same horizon.

Middle Cambrian: Fu-chóu series. Shales about 130 feet (40 m.) above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general section showing stratigraphic relations]; collected in a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria.

Obolus damesi
Lingulella marcia
Acrotreta shantungensis
Agnostus chinensis
Anomocare minus
Bathyuriscus manchuriensis

36i. Below 35*q*; above 36*h*.

Middle Cambrian: Fu-chóu series. Approximately 175 feet (53 m.) above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general section showing stratigraphic relations]; collected in a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria.

No identifiable species.

36j. Above 35*q*; below 36*f*.

Middle Cambrian: Fu-chóu series. Approximately 500 feet (152 m.) above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general section showing stratigraphic relations]; collected in a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria.

LIST OF ALL SPECIES FROM LIAU-TUNG, MANCHURIA, WITH LOCALITY NUMBERS.

Protospongia chloris Walcott (35*n* Limestone) (35*q*).
Protospongia sp. undt. (spicules) (35*n* Limestone).
Planolites (annelid trails) (36*f* Limestone and shale).
Micromitra sculptilis Meek (35*n*) (35*r* Limestone).
Micromitra (*Paterina*) *lucina* Walcott (35*n*) (35*r* Limestone) (36*d*).
Micromitra (*Iphidella*) *pannula maladensis* Walcott (35*n*) (35*r* Limestone).
Micromitra (*Iphidella*) *pannula ophirensis* Walcott (35*n* Limestone).
Obolus chinensis Walcott (35*n* Limestone).
Obolus damesi Walcott (35*n* Limestone) (35*o*) (35*r*) (36*d*) (36*e* Shale) (36*g*) (36*h* Shale).
Obolus shansiensis Walcott (35*r* Limestone).
Lingulella manchuriensis Walcott (35*p* Shale).
Lingulella marcia Walcott (35*q*) (? 36*f* Limestone and shale) (36*h* Shale).
Acrothele matthewi eryx Walcott (35*n* Limestone) (35*o*) (35*r*) (36*d*) (36*e* Shale) (36*g*).
Acrotreta pacifica Walcott (35*p* Shale).
Acrotreta shantungensis Walcott (35*n* Limestone) (35*o*) (35*r*) (36*g*) (36*h* Shale).
Acrotreta venia Walcott (35*q*).
Hyolithes cybele Walcott (35*n* Limestone) (35*r*).
Orthotheca cyrene Walcott (35*n* Limestone).
Orthotheca delphus Walcott (35*n* Limestone) (35*r*).
Orthotheca cf. *delphus* Walcott (36*g*).
Orthotheca glabra Walcott (35*n* Limestone).
Agnostus chinensis Dames (35*n* Limestone) (35*o*) (35*p*) (35*r*) (36*e* Shale) (36*g*) (36*h* Shale).
Agnostus douvilléi Bergeron (36*f* Limestone and shale).
Albertella pacifica Walcott (36*f* Limestone and shale).
Dorypyge richthofeni Dames (35*n*) (35*p* Shale) (35*r* Limestone).
Teinistion typicalis Walcott (36*f* Limestone and shale).
Stephanocare sinensis Bergeron (36*f* Limestone and shale).
Blackwelderia sinensis Bergeron (36*f*).
Damesella blackwelderi Walcott (35*q*) (36*f* Limestone and shale).
Damesella sp. undt. (35*o*).
Drepanura premesnili Bergeron (36*f* Limestone and shale).
Ptychoparia kochibei Walcott (35*n*) (35*r* Limestone) (36*e* Shale).
Ptychoparia typus Dames (35*o*).
Crepicephalus convexus Walcott (35*r* Limestone).
Liostracina krausei Monke (36*f* Limestone and shale).
Pterocephalus liches Walcott (35*n* Limestone).
Shantungia spinifera Walcott (36*f* Limestone and shale).
Agraulos sorge Walcott (35*n* Limestone).
Solenopleura agno Walcott (35*r* Limestone).
Solenopleura beroe Walcott (35*n* Limestone).
Solenopleura chalcon Walcott (35*r* Limestone).
Solenopleura sp. undt. (35*n* Limestone).
Anomocare ephori Walcott (35*n*) (35*r* Limestone).
Anomocare latelimbatum Dames (35*n* Limestone).
Anomocare lisani Walcott (35*q*).
Anomocare megalurus Dames (35*n* Limestone).
Anomocare minus Dames (35*n* Limestone) (36*e* Shale) (36*h*).
Anomocare minus Dames var. undt. (35*n* Limestone) (36*e* Shale).
Anomocare subquadratum Dames (35*n* Limestone).
Anomocarella chinensis Walcott (35*n*) (35*r* Limestone) (36*g*).
Anomocarella hermias Walcott (35*n* Limestone).
Anomocarella macar Walcott (35*n* Limestone).
Anomocarella temenus Walcott (35*n* Limestone) (35*r*).
Dolichometopus deois Walcott (35*o*) (35*p* Shale) (35*r* Limestone).
Bathyuriscus manchuriensis Walcott (35*o*) (36*g*) (36*h* Shale).
Asaphiscus iddingsi Walcott (35*r* Limestone) (36*e*).

GEOLOGICAL CONDITIONS.

PRE-CAMBRIAN CONTINENTAL CONDITIONS.

The material composing the surface of the land that was awaiting the advance of the Cambrian sea must have been, as described by Willis, very largely made up of clays and sands resulting from the long disintegration of the continental surface at a relatively low relief. Applying this conclusion, we infer that the Asiatic continent at the beginning of Cambrian time was practically a featureless continent and that the transgressing Cambrian sea gradually rose, carrying with it the marine life that developed in the sea on the continental slopes during the long period in which the pre-Cambrian continental surface had been worn down nearly to base-level.

If we now turn to the life contained in the first series of deposits, the Man-t'o formation, we find that it represents the closing epoch of Lower Cambrian time that succeeded the faunas of the *Olenellus* epoch of the older western American formations, and the traces of the Lower Cambrian fauna that have been found in Siberia. The presence of a portion of the later Lower Cambrian fauna in Siberia indicates that this portion of the Asiatic continent was at a lower level and hence was traversed at an earlier epoch by the Cambrian sea than the portions of southeastern and southern Asia, which include Manchuria, eastern and southern China, and northern India.

The relations of the Cambrian strata to the subjacent rocks compel the conclusion that the Asiatic continent was a land surface during the earlier part of Cambrian time and during the long Lipalian interval [Walcott, 1910*b*, p. 14] represented by the deposition of the great series of pre-Cambrian sedimentary rocks on the North American continent and the lesser series on the Asiatic continent, described by Willis as the Wu-t'ai and the Hu-t'o systems. [Willis, 1907, pp. 4–20.]

In speaking of the rocks of the Hu-t'o system he says:

> All of the rocks of the Hu-t'o system are sedimentary strata: conglomerate, quartzite, shale, and limestone, which resemble the unmetamorphosed Paleozoic rocks more nearly than they do the Wu-t'ai schists. The physical events which intervened between the close of the Wu-t'ai period and the beginning of the Hu-t'o involved greater changes and probably longer time than those which occurred after the Hu-t'o and before the Sinian; but the presence of a rich fauna in the Sinian seas distinguishes that period from the preceding time, during which the life forms, though probably numerous, did not generally become fossil. The nearest relations of the Hu-t'o system are with the Belt terrane of Montana (in America), and it is probable that pre-Cambrian fossils[1] such as have been found in the Belt may eventually be discovered in the Hu-t'o. [Willis, 1907, p. 7.]

In the above-quoted paragraph Doctor Willis unconsciously gives a strong argument for the non-marine origin of the rocks of the Hu-t'o system when

[1]Pre-Cambrian fossiliferous formations, C. D. Walcott, Bull. G. S. A., vol. x, p. 199, 1899.

he says that the presence of a rich fauna in the Sinian seas distinguishes that period from the preceding (Hu-t'o) time. It was the absence of marine life and the character of the sediments that led me to conclude that there were no marine deposits on the North American continent (nor probably on any of the continents) representing the Lipalian interval or the interval between the fossiliferous Cambrian formations and the period of the development of the early pre-Cambrian marine life along the shores of the continents. [Walcott, 1910*b*, pp. 14–15.]

I now anticipate that if the rocks of the Wu-t'ai and Hu-t'o systems are studied with the view that they may not be of marine origin, they will be found to have been deposited as epicontinental sediments accumulated on flood plains or in bodies of fresh water. In part they are more altered and metamorphosed than the pre-Cambrian sedimentary rocks of North America, and hence it may be more difficult to determine their origin.

UNCONFORMITY AT BASE OF CAMBRIAN.

Dr. Bailey Willis has given a very clear and full description of the Sinian system, the lower portion of which is referred to the Cambrian [Willis, 1907, pp. 35–49]. He found the unconformity at the base of the Sinian that divided the Paleozoic from the pre-Cambrian to be a break of the first magnitude even where the underlying strata are the Ta-yang (Nan-k'ou) limestone of the late Proterozoic [Willis, 1907, p. 31]:

> The mechanical sediment of the basal formation has the character of a fine alluvium and is of uniform moderate thickness, 350 to 500 feet, 105 to 150 meters. The material is red soil, particles of ferruginous clay being thoroughly oxidized and grains of sand coated with ferric oxide. The plane of contact at the base is sharply defined, usually very even, not broken by abrupt hollows or decided projections, but swelling gently over rounded bosses of the harder rocks. Pebbles of the subjacent rocks are wanting in the basal deposits, as a rule, and where they occur are limited to very local accumulations. Beds of arkose have not been seen, nor even beds of clean sand such as waves usually spread. Thus none of the effects of violent breakers are present; the evidence is that a gentler agent cleaned the surface of the ancient rocks. The facts support the view that the lowest strata of the Man-t'o formation were laid down in the shallows, lagoons, and flood-plains of a very low, flat coast, where weak waves, feeble shore currents, and rivers interacted. [Willis, 1907, p. 32.]

In discussing the unconformity at the base of the Sinian, Doctor Willis states that each unconformity is somewhere represented by continuous, conformable deposits, and the area of unconformity is bounded by areas of conformity:

> When we pass from one to the other there is difficulty in dividing the continuous series of strata at a plane corresponding to that indicated by the discontinuity in the neighboring series. This condition exists at the base of the Cambrian in certain localities in the United States, where the lowest fossiliferous Cambrian strata are conformably underlain by great thicknesses of sediments, that accumulated in the depressions from which the Cambro-Ordovician epicontinental sea expanded. Such sediments are by some regarded as pre-Cambrian, by some as the downward extension of the Cambrian. There is no difference of opinion regarding the base in sections where the unconformity intervenes, as is commonly the case. [Willis, 1907, p. 35.]

Since Willis wrote the above in 1907, I have completed my study of the relations of the Cambrian and pre-Cambrian in North America and have concluded that the pre-Cambrian unconformity is universal in all known localities of Cambrian sedimentation and that the depressions in which the pre-Cambrian sediments were deposited were epicontinental, mainly non-marine, and in no way connected directly with the subsequent Cambrian sedimentation. [Walcott, 1910*b*, pp. 2–3.]

THE GEOLOGIC FORMATIONS.

LOWER SINIAN, MAN-T'O SHALE.

The basal formation, the Man-t'o, is a red shale that passes often into red or chocolate-brown shaly sandstone, and this is interbedded with thin, sometimes persistent, layers of gray, cream-colored limestone. The thickness varies from 350 to 500 feet (105 to 150 meters). The basal layers occasionally show local conglomerates. The calcareous layers of the Man-t'o occur occasionally near the base, persistently at horizons 100 to 150 feet (30 to 45 meters) higher up, and again less commonly near the top, which is often sandy. The transition into the overlying limestone of the Kiu-lung group is formed of interbedded brown shales and gray limestones.

The interbedding of the shale and limestone is irregular. It is apparent that local conditions were unlike in adjacent waters at any one time and varied in unlike manner from time to time, but red sediment from the land or calcareous sediment from the sea was deposited at any time, as stated by Willis [1907, p. 38], who also says:

> One may form a concept of the conditions somewhat as follows: Along the flat, red shore of the Man-t'o sea, bars and islands formed where streams emptied, and shut off the mud-carrying currents from intermediate stretches of coast. More or less extensive lagoons were thus produced and within these the waters were clear. Being partly closed and shallow, they were relatively warm and liable to maximum evaporation. Rippling of the surface favored precipitation of lime carbonate by agitation. Warmth and protection invited organic life, both plant and animal, which probably occupied the lagoons in low forms that did not become fossil before trilobites, the earliest that have been preserved, discovered the habitat.
>
> The description of the Man-t'o formation has thus far dealt with it as it is developed in northern China. The red mud does not occur in the south on the Yang-tzï-kiang, where we saw the base of the Sinian, but the strata which we suppose to be equivalent are thin-bedded gray limestones which rest on a well-defined glacial till. [Willis, 1907, pp. 38–39.]

The geological conditions thus briefly outlined clearly indicate that the Man-t'o formation was the first deposit made over a wide area by the slowly transgressing Cambrian sea. This area is outlined by Willis on his map of "Southern Asia during the Sinian Period" [1907, plate 4].

MIDDLE SINIAN, KIU-LUNG GROUP.

Willis describes this group in the following words:

> The Kiu-lung group of Shan-tung is a succession of limestones and shales which immediately follows the Man-t'o formation. Transition beds connect the two. Shale is a common rock in both, but in the Man-t'o it is red, whereas in the Kiu-lung it is green. Limestone is thin-bedded and subordinate in the former; in the latter it is usually massive

and predominant. The Man-t'o contains a sparse Middle or Lower Cambrian fauna in its upper portion; the Kiu-lung carries very abundant faunas, which range from Middle Cambrian at the base to Upper Cambrian and possibly to lowest Ordovician at the top. [Willis, 1907, p. 40.]

The Kiu-lung group is divided into the Ch'ang-hia limestone at the base, the Ku-shan shale, and the Ch'au-mi-tién limestone.

Ch'ang-hia limestone.—The lower portion of the Kiu-lung group is composed of green shale and limestone, alternating in character and forming a series 400 to 500 feet thick (120 to 150 meters).

Ku-shan shale.—The middle portion of the group is characterized by dominance of shale, and Doctor Willis gave it the name of the Ku-shan shale in the vicinity of Shan-si, where a single stratum occurs 150 feet (45 meters) thick.

Ch'au-mi-tién limestone.—The upper part of the Kiu-lung group, the Ch'au-mi-tién limestone, horizontally maintains a uniform character. It is given a thickness of from 400 to 600 feet (120 to 185 meters). It represents a widespread condition of deposition.

The Upper Sinian, the Tsi-nan limestone, differs in lithologic characters and also contains fossils of Lower Ordovician type.[1]

The lower portion of the Kiu-lung group is designated as the Ch'ang-hia limestone in the Ch'ang-hia district, and in the Sin-t'ai district as the lower limestone. Blackwelder gives the reason for this as follows:

> The classification of the Kiu-lung group into three separate divisions is not appropriate for this district, in spite of the fact that the general paleontologic horizons of the Ch'ang-hia area are recognized here with ease. The black oolite is much reduced in thickness, and is largely replaced by shales. The Ku-shan shale is thicker and carries fossils which belong to the Ch'ang-hia and Ch'au-mi-tién formations, respectively, in its upper and lower portions. The Ch'au-mi-tién limestone alone retains the general character noted in the first area studied, but its base is somewhat shifted. Thus, the Kiu-lung, which in the Ch'ang-hia district is a group composed of three formations, is in the Sin-t'ai district a consistent formation, containing members of limestone and shale, which are of local occurrence only. [Blackwelder, 1907, pp. 36–37.]

RELATION OF THE CAMBRIAN TO THE ORDOVICIAN.

The Ch'au-mi-tién limestone is described by Blackwelder as a very dark gray, finely crystalline rock that has a distinctly blue color where exposed to the weather. The summit of the formation is marked by a change in the character of the sediments, the lower member of the next younger series being yellowish in color and notably dolomitic.[2]

The Tsi-nan formation above the Cambrian is one of the most widely distributed formations in China and is readily recognized by the light-colored argillaceous limestones or dolomites and thin shales of its lower member and the brown dolomitic limestone of its upper member.[3]

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[1] The Cambrian portion of the Sinian is described in detail with sections and distribution of faunas by Dr. Eliot Blackwelder in his description of the stratigraphy of Shan-tung [Blackwelder, 1907, vol. I, part I, pp. 19–58] and in the description of the stratigraphy of Chĭ-li in Shan-si [1907, pp. 136–147], so that it will not be necessary for me to go further into the details of sedimentation and stratigraphy.

[2] Blackwelder, 1907, pp. 34, 35. [3] Idem, p. 44.

The Tsi-nan formation is referred to the Ordovician on the evidence of fossils found in its upper member. No fossils were found in the lower portion.[1]

The transition from the Upper Cambrian to the Tsi-nan formation is not marked by an unconformity, but the introduction of argillaceous and dolomitic limestones indicates a change in sedimentation that was brought about by diastrophic action that revived erosion and ultimately led to the great epeirogenic changes that marked the close of the Sinian. The fauna of the Cambrian disappeared, so far as known, everywhere in the western Pacific Province and the faunas of Ozarkian[2] and Canadian time did not flourish in the Tsi-nan sea, and apparently entered it only at rare intervals. It may be that faunas corresponding to the Lake Champlain and Mississippi Valley Canadian and Ozarkian will be found on the Asiatic continent, but at present we must be content to close the Cambrian with the upper horizon of the Kiu-lung group, and wait for further data on the faunas of the Tsi-nan formation and their relation to the Cambrian and Lower Ordovician faunas of North America and Europe.

The presence of the genera *Syntrophia*, *Huenella*, *Cyrtoceras*, and *Illænurus* in the Ch'au-mi-tién limestone proves that the Upper Cambrian fauna was beginning to assume a post-Cambrian aspect toward the close of the deposition of the Ch'au-mi-tién limestone. It is quite possible that the fauna of the lower portion of the Tsi-nan formation, when found, will have an Upper Cambrian aspect, but it is more probable that it will have the general facies of that of the lower Pogonip of the Nevada Cordilleran sections.[3]

At present the trilobitic fauna of the Upper Cambrian in the Pacific and Cordilleran provinces is readily recognizable at nearly all localities by the presence of such genera of trilobites as *Ptychaspis*, *Illænurus*, and various genera of the Ptychoparidæ. *Dikelocephalus* is restricted in geographic distribution to a few localities in North America. I would place the formations containing a typical Cambrian trilobitic fauna in the Cambrian, and where a formation has a fauna characterized by a new group of forms that evidently belong to a later fauna it should be assigned to a post-Cambrian system even though it may have a few Cambrian genera of trilobites included in it.

In North America we find that the fauna of the Upper Cambrian in the Cordilleran region is quite distinctly marked by the presence of typical Cambrian genera and the absence of typical post-Cambrian genera. In the central area between the Rocky Mountains and the Appalachians the Upper Cambrian fauna as characterized by the trilobitic genera *Agnostus*, *Ptychaspis*, *Dikelocephalus*, *Ptychoparia*, and *Illænurus* is singularly free from commingling of typical post-Cambrian genera except in the case of the Gasconade fauna, where a few trilobitic genera, notably *Dikelocephalus*, have persisted into Ozarkian time.[4]

[1] Blackwelder, 1907, pp. 44–46.
[2] Ulrich, 1911, p. 627.
[3] Walcott, 1884*b*, p. 3.
[4] Ulrich, 1911, p. 631.

PALEONTOLOGY.

STRATIGRAPHIC AND GEOGRAPHIC DISTRIBUTION OF SPECIES.

The table gives the general stratigraphic and geographic distribution of the Chinese species described in this memoir. The asterisk used opposite the species by authors to indicate the position of the species is replaced by the locality number or numbers to enable the student to refer to the exact locality, stratigraphic position, and lists of associated species. [See pp. 15–28 for list of localities and associated species.]

The following is a summary of the genera and species:

Classification.	Genera.	Subgenera.	Species.	Varieties.
Foraminifera	1	.....	1	.....
Porifera	2	.....	2	.....
Anthozoa	1	.....	1	.....
Annelida	1	.....	1	.....
Brachiopoda	13	4	36	4
Gastropoda	5	.....	11	2
Pteropoda	2	.....	11	1
Cephalopoda	1	.....	1	.....
Trilobita	36	1	175	4
Ostracoda	1	.....	6	.....
	63	5	245	11

General Stratigraphic and Geographic Position of the Cambrian Faunas of China.

Name.	Page.	Plates.	Stratigraphic position.			General geographic position.		
			Lower Cambrian.	Middle Cambrian.	Upper Cambrian.	Near Yen-chuang.	Near Wu-t'ai-hién.	Tschang-hsing-tau Island.
FORAMINIFERA.								
Globigerina ? mantoensis	59	1	....	×	....	C 5	....	.....
PORIFERA.								
Protospongia chloris	59	1	....	×	....	C 1, C 2, C 4	....	35 *n*, 35 *q*
Protospongia sp. undt	60	1	....	×	....	.....	.....	35 *n*
ANTHOZOA.								
Coscinocyathus elvira	60	1	....	×	....	.....	C 75	.....
ANNELIDA.								
Planolites sp. undt	61	1	....	×	....	.....	.....	36 *f*
BRACHIOPODA.								
Micromitra sculptilis	61	1	....	×	....	.....	.....	35 *r*, 35 *n*
Micromitra (Paterina) labradorica orientalis	62	1	....	×	....	C 9	.....	.....
Micromitra (Paterina) lucina	62	1	....	×	....	.....	.....	35 *n*, 35 *r*, 36 *d*
Micromitra (Iphidella) pannula maladensis*	63	1	....	×	....	.....	.....	35 *n*, 35 *r*
Micromitra (Iphidella) pannula ophirensis†	63	1	....	×	....	C 5	.....	35 *n*
Obolus chinensis	64	1	....	×	....	C 62	.....	35 *n*

*Also occurs in Idaho and Newfoundland. †Also occurs in Utah.

NOTE.—The columns "Near Ch'ang-hia," "Near Ch'au-mi-tién," "Near Sin-t'ai-hién," "Near Tsi-nan," "Near Fang-lan-chön," "Near Tung-yü," "Near Chön-ping-hién," "Near Ting-hiang-hién," and "Near Kao-kia-p'u" are omitted in this page, as the species recorded in the first column were not collected in those localities.

General Stratigraphic and Geographic Position of the Cambrian Faunas of China—Continued.

Name.	Page.	Plates.	Stratigraphic position.			General geographic position.										
			Lower Cambrian.	Middle Cambrian.	Upper Cambrian.	Near Ch'ang-hia.	Near Yen-chuang.	Near Ch'au-mi-tién.	Near Wu-t'ai-hién.	Near Tsi-nan.	Near Fang-lan-chön.	Near Tung-yü.	Near Chön-p'ing-hién.	Near Ting-hiang-hién.	Near Kao-kia-p'u.	Tschang-hsing-tau Island.
BRACHIOPODA—Continued.																35*n*, 35*o*
Obolus damesi	65	2		×			C 7, C 10, C 64									35*r*, 36*d*, 36*e*, 36*g*, 36*h*
Obolus matinalis ?	65	2			×					C 54, C 67?						
Obolus minimus	66	2		×			C 1									
Obolus obscurus	66	1		×			C 63		C 75							
Obolus shansiensis	67	2		×								C 71?	C 32	C 37		35*r*
Obolus (Westonia) blackwelderi	68	2		×			C 1, C 2, C 6									
Obolus (Westonia) sp. undt.	69				×					C 56						
Lingulella manchuriensis	69	3		×												35*p*
Lingulella marcia	69	2		×												35*q*, 36*f*?, 36*h*
Lingulella (Lingulepis) eros.	70	3		×			C 7									
Lingulella (Lingulepis ?) sp. undt.	70			×							C 72					
Dicellomus parvus	71	3		×			C 6						C 32			
Obolella asiatica	72	3	×			C 17							C 32′			
Yorkia ? orientalis	72	3		×								C 71				
Acrothele matthewi eryx	73	3		×			C 4									35*n*, 35*o*, 35*r*, 36*e*, 36*g*
Acrothele ? minuta	74	3		×			C 6									
Acrothele rara	74	3		×		C 23									C 57	
Acrotreta lisani	75	3		×		C 22										
Acrotreta pacifica	75	4		×		C 24?	C 1, C 2, C 4, C 5, C 12									35*p*
Acrotreta shantungensis	76	4		×			C 1?, C 62					C 71	C 32	C 37		35*n*, 35*o*, 35*r*, 36*g*, 36*h*
Acrotreta venia	77	3		×												35*q*
Discinopsis sulcatus	79	4			×					C 56						
Billingsella pumpellyi	79	4			×		C 61	C 36								
Billingsella richthofeni	80	4	×			C 20	C 3									
Eoorthis agreste	81	4		×		C 28										
Eoorthis doris	81	4			×		C 64									
Eoorthis kayseri	82	4			×		C 64	C 68			C 74					
Eoorthis kichouensis	82	4		×					C 75							
Eoorthis linnarssoni	83	4			×		C 64			C 67?						
Eoorthis pagoda	83	4			×					C 54, C 56						
Eoorthis sp. undt. (*a*)	84	4		×		C 26										
Eoorthis sp. undt. (*b*)	85	4		×								C 71				
Huenella orientalis	85	4			×		C 64									
Syntrophia orthia	85	5			×		C 64			C 54, C 56						

NOTE.—The column "Near Sin-t'ai-hién" is omitted in this page, as the species recorded in the first column were not collected in that locality.

General Stratigraphic and Geographic Position of the Cambrian Faunas of China—Continued.

Name.	Page.	Plates.	Stratigraphic position.			General geographic position.								
			Lower Cambrian.	Middle Cambrian.	Upper Cambrian.	Near Ch'ang-hia.	Near Yen-chuang.	Near Ch'au-mi-tién.	Near Tsi-nan.	Near Fang-lan-chön.	Near Tung-yü.	Near Chön-p'ing-hién.	Near Kao-kia-p'u.	Tschang-hsing-tau Island.
GASTROPODA.														
Scenella clotho	86	5		×		C 18								
Scenella ? dilatatus	87	5		×							C 70			
Scenella sp. undt	87	5			×				C 56					
Matherella circe	88	5			×				C 56					
Straparollina sp. undt	88	5		×					C 55					
Pelagiella chronus	88	5		×		C 18	C 1, C 4							
Pelagiella clytia	89	5			×			C 47						
Pelagiella pagoda	89	5			×				C 56					
Pelagiella willisi	90	5		×						C 72				
Helcionella ? clurius	90	5		×				C 46						
Helcionella rugosa chinensis	91	5	×				C 3							
Helcionella rugosa orientalis	91	5		×		C 18, C 21								
Helcionella ?? simplex	92	5		×							C 70			
PTEROPODA.														
Hyolithes cybele	92	5, 6		×		C 22	C 1, C 2, C 4, C 62							35n, 35r
Hyolithes daphnis	93	5			×		C 64							
Hyolithes delia	94	5	×				C 3							
Hyolithes sp. undt	94	5	×				C 4?					C 32'		
Orthotheca cyrene	94	5		×	×		C 64	C 47						35n
Orthotheca cyrene dryas	95	5		×			C 2							
Orthotheca daulis	95	5		×		C 23								
Orthotheca delphus	96	6		×			C 4						C 57	35n, 35r
Orthotheca cf. delphus	97			×										36g
Orthotheca doris	97	6		×								C 32		
Orthotheca glabra	97	5, 6		×						C 72	C 71			35n
Orthotheca sp. undt	98	6			×				C 56					
CEPHALOPODA.														
Cyrtoceras cambria	98	6			×				C 56					
TRILOBITA.														35n, 35o
Agnostus chinensis	99	7		×			C 1, C 2, C 4				C 71		C 57	35p, 35r, 36e, 36g, 36h
Agnostus douvilléi	100	7, 11		×			C 6		C 55					36f
Agnostus kushanensis	101	7		×									C 57	
Agnostus parvifrons latelimbatus*	102	7		×										
Microdiscus orientalis	102	7		×								C 32		
Shumardia sp. undt		7		×				C 51						
Redlichia chinensis	104	7, 24	×			C 15, C 16, C 27								
Redlichia ? finalis	105	7		×									C 58	
Redlichia nobilis	105	7	×				C 3							
Redlichia sp. undt (*a*)	105	7		×			C 6							
Redlichia sp. undt (*b*)	106	7	×			C 16								
Redlichia sp. undt (*c*)	106	7	×			C 27	C 60							
Albertella pacifica	106	12		×										36f
Dorypyge bispinosa	107	8		×			C 2							

*Occurs at Wang-tschuang, Shan-tung, China.

NOTE.—The columns "Near Sin-t'ai-hién," "Near Wu-t'ai-hién," and "Near Ting-hiang-hién," are omitted in this page, as the species recorded in the first column were not collected in those localities.

General Stratigraphic and Geographic Position of the Cambrian Faunas of China—Continued.

Name.	Page.	Plates.	Stratigraphic position.			General geographic position.									
			Lower Cambrian.	Middle Cambrian.	Upper Cambrian.	Near Ch'ang-hia.	Near Yen-chuang.	Near Ch'au-mi-tién.	Near Sin-t'ai-hién.	Near Wu-t'ai-hién.	Near Tsi-nan.	Near F'ang-lan-chön.	Near Tung-yü.	Near Kao-kia-p'u.	Tschang-hsing-tau Island.
TRILOBITA—Continued.															
Dorypyge richthofeni	108	8	....	×	....	C 19, C 24, C 29, C 30	C 1	....	....	....	....	....	....	C 57	35n, 35p, 35r
Dorypyge richthofeni lævis.	109	8	....	×	....	....	C 12	....	....	....	....	C 72	C 71	....	....
Teinistion alcon	110	9	....	×	....	....	C 6, C 12	....	....	....	....	....	....	....	....
Teinistion lansi*	111	9	....	....	....	....	C 12	....	....	....	....	....	....	....	....
Teinistion typicalis	111	9	....	×	....	....	C 12	....	....	....	....	....	....	....	36f
Stephanocare ? monkei	113	8	....	×	....	....	C 6	....	....	....	....	....	....	....	....
Stephanocare richthofeni	114	7	....	×	....	....	C 6	....	....	....	C 55	....	....	....	....
Stephanocare ? sinensis	116	8	....	×	....	....	C 6	....	....	....	....	....	....	....	36f
Stephanocare ? sp. undt.	116	8	....	×	....	....	C 6	....	....	....	....	....	....	....	....
Blackwelderia alastor	117	9	....	×	....	....	C 12	....	....	....	....	....	....	....	....
Blackwelderia cilix	119	9	....	×	....	....	....	....	....	....	C 55	C 73	....	....	....
Blackwelderia sinensis†	121	9	....	×	....	....	C 6	....	....	....	....	....	....	....	36f
Damesella bellagranulata	125	9	....	×	....	....	C 13	....	....	....	....	....	....	....	....
Damesella blackwelderi	125	10	....	×	....	....	C 12, C 13, C 14, C 40	....	....	....	....	....	....	....	35q, 36f
Damesella brevicaudata	128	9	....	×	....	C 19	....	....	....	....	....	....	....	....	....
Damesella sp. undt. (c)	128	9	....	×	....	....	....	C 46	....	....	....	....	....	....	35o
Drepanura ketteleri	129	10	....	×	....	....	C 6	....	....	....	C 55	....	....	....	....
Drepanura premesnili	129	10, 11	....	×	....	....	C 6	....	....	....	C 55	....	....	....	36f
Ptychoparia aclis	130	12	×	....	....	C 17, C 20, C 31	....	....	....	....	....	....	....	....	....
Ptychoparia granosa	131	12	×	....	....	C 17	....	....	....	....	....	....	....	....	....
Ptychoparia impar	131	12	×	....	....	C 17	....	....	....	....	....	....	....	....	....
Ptychoparia impar var. ?	132	12	....	×	....	....	C 8	....	....	....	....	....	....	....	....
Ptychoparia kochibei	132	12	....	×	....	....	....	....	....	....	....	....	....	....	35n, 35r, 36e
Ptychoparia ligea	133	12	×	....	....	C 31	....	....	....	....	....	....	....	....	....
Ptychoparia lilia	133	12	....	×	....	....	....	....	....	C 75	....	....	....	....	....
Ptychoparia ? tolus	134	12	....	×	....	....	....	....	C 52	....	....	....	....	....	....
Ptychoparia typus	134	12	....	×	....	....	....	....	....	....	....	....	....	....	35o
Ptychoparia spp. undt.	....	12	....	×	....	....	C 4, C 5	C 48	....	....	....	....	....	C 58	....
Ptychoparia (Emmrichella) bromus	135	13	....	×	....	....	C 6	....	....	....	....	....	....	....	....
Ptychoparia (Emmrichella) constricta	135	13	×	....	....	....	C 3	....	....	....	....	....	....	....	....
Ptychoparia (Emmrichella) eriopia	136	13	....	×	....	C 23	....	....	....	....	....	....	....	....	....
Ptychoparia (Emmrichella) mantoensis	136	13	×	....	....	C 20, C 31	....	....	....	....	....	....	....	....	....
Ptychoparia (Emmrichella) theano	136	13	....	×	....	C 23	....	....	....	....	....	....	....	....	....
Conokephalina belus	138	13	....	....	×	....	....	....	....	....	C 56	....	....	....	....
Conokephalina dryope	138	13	....	....	×	....	....	....	....	....	C 56	....	....	....	....
Conokephalina maia	139	13	....	×	....	....	....	....	....	....	....	....	C 70	....	....
Conokephalina vesta	139	13	....	×	....	....	....	....	....	....	....	C 69	....	....	....
Conokephalina sp. undt.	140	13	....	×	....	....	....	....	....	....	....	C 72	C 70	....	....
Crepicephalus convexus	140	13	....	×	....	....	....	....	....	....	....	....	....	....	35r
Crepicephalus damia	141	13	....	×	....	C 18, C 21, C 26	....	....	....	....	....	....	C 71	....	....
Crepicephalus magnus	142	13	....	×	....	C 25?, C 18	....	C 48	....	....	....	....	....	....	....
Lonchocephalus tellus	143	14	....	×	....	....	C 2	....	....	....	....	....	....	....	....
Liostracina krausei	143	11, 14	....	×	....	....	C 6	....	....	....	....	....	....	....	36f
Proampyx burea	145	14	....	....	×	....	C 61	....	....	....	....	....	....	....	....

*Also from Yen-tsy-yai. †*Calymmene ? sinensis* Bergeron.

NOTE.—The columns "Near Chön-ping-hién" and "Near Ting-hiang-hién" are omitted in this page, as the species recorded in the first column were not collected in those localities.

General Stratigraphic and Geographic Position of the Cambrian Faunas of China—Continued.

Name.	Page.	Plates.	Stratigraphic position.			General geographic position.								
			Lower Cambrian.	Middle Cambrian.	Upper Cambrian.	Near Ch'ang-hia.	Near Yen-chuang.	Near Ch'au-ni-tién.	Near Sin-t'ai-hién	Near Wu-t'ai-hién.	Near Tsi-nan.	Near Fang-lan-chön.	Near Tung-yü.	Tschang-hsing-tau Island.
TRILOBITA—Continued.														
Pterocephalus asiaticus	146	14		×			C 12							
Pterocephalus busiris	146	14			×		C 61				C 54			
Pterocephalus ? liches	147	14		×										35*n*
Shantungia spinifera	148	11, 14		×			C 6							36*f*
Inouyia abaris	149	14		×			C 7, C 9							
Inouyia ? acalle	150	14		×			C 12							
Inouyia armata	150	14		×						C 75				
Inouyia capax	151	14		×									C 70	
Inouyia divi	152	14		×		C 24	C 1, C 5							
Inouyia ? inflata	152	14		×								C 69		
Inouyia melie	153	14		×						C 75			C 70	
Inouyia ? regularis	154	14		×								C 73		
Inouyia thisbe	154	14		×		C 28								
Inouyia titiana	155	14		×			C 7							
Agraulos abrota	156	15		×		C 23								
Agraulos dirce	156	15		×					C 52					
Agraulos dolon	156	15		×			C 7							
Agraulos dryas	157	14		×		C 29								
Agraulos nitida	158	15		×						C 75				
Agraulos obscura	158	15		×								C 69		
Agraulos sorge	159	15		×										35*n*
Agraulos uta	159	15		×						C 75				
Agraulos vicina	160	15		×									C 70	
Pagodia bia	161	15			×						C 56			
Pagodia dolon	161	15			×			C 41						
Pagodia lotos	162	15			×						C 56			
Pagodia macedo	163	15			×			C 34						
Lisania agonius	164	15		×			C 1, C 2							
Lisania ajax	165	15		×			C 12, C 40							
Lisania alala	165	15		×		C 22, C 30	C 4	C 46, C 51						
Lisania ? belenus	166	15		×		C 19								
Lisania bura	166	15		×		C 22								
Lisania cf. bura	166	15		×						C 77				
Lisania sp. undt	167	15		×	×	C 30		C 41						
Solenopleura agno	167	17		×		C 25		C 51						35*r*
Solenopleura beroe	168	17		×	×		C 64							35*n*
Solenopleura chalcon	168	17		×										35*r*
Solenopleura intermedia	169	17		×				C 51						
Solenopleura pauperata	169	17		×									C 71	
Solenopleura sp. undt	170			×		C 21								35*n*
Chuangia batia	170	17			×		C 11, C 61, C 64	C 44	C 33*a*					
Chuangia fragmenta	171	16			×		C 61							
Chuangia nais	171	16			×		C 64							
Chuangia nitida	172	17			×		C 11							
Menocephalus abderus	173	16		×		C 19								
Menocephalus acanthus	173	16		×		C 22								
Menocephalus acerius	174	16		×		C 18								
Menocephalus acidalia	174	16		×		C 30								
Menocephalus acis	175	16		×				C 35						
Menocephalus admeta	175	16		×		C 22								
Menocephalus agave	176	16		×		C 30								
Menocephalus ? depressus	176	16			×			C 49			C 56			
Menocephalus ? sp. undt	176	16		×		C 30	C 10							
Levisia adrastia	177	16		×		C 30								
Levisia agenor	178	14		×		C 25								
Ptychaspis acamus	179	16			×			C 45						

NOTE.—The columns "Near Chön-p'ing-hién," "Near Ting-hiang-hién," and "Near Kao-kia-p'u" are omitted in this page, as the species recorded in the first column were not collected in those localities.

General Stratigraphic and Geographic Position of the Cambrian Faunas of China—Continued.

Name.	Page.	Plates.	Stratigraphic position.			General geographic position.										
			Lower Cambrian.	Middle Cambrian.	Upper Cambrian.	Near Ch'ang-hia.	Near Yen-chuang.	Near Ch'au-mi-tiên.	Near Sin-t'ai-hién.	Near Wu-t'ai-hién.	Near Tsi-nan.	Near Fang-lan-chön.	Near Tung-yü.	Near Ting-hiang-hién.	Near Kao-kia-p'u.	Tschang-hsing-tau Island.
TRILOBITA—Continued.																
Ptychaspis baubo	179	17			×		C 61, C 64									
Ptychaspis bella	180	17			×							C 74				
Ptychaspis brizo	181	17			×			C 38								
Ptychaspis cacus	181	17			×		C 64									
Ptychaspis cadmus	182	16			×			C 41								
Ptychaspis calchas	183	16			×			C 41								
Ptychaspis callisto	183	16			×		C 64									
Ptychaspis calyce	184	16			×		C 64	C 42								
Ptychaspis campe	184	16			×			C 42								
Ptychaspis ceto	185	16			×		C 64	C 34, C 38, C 45			C 54, C 56					
Ptychaspis spp. undt	186	17,21			×		C 64	C 47, C 50	C 33		C 54, C 67					
Anomocare alcinoe	187	18		×											C 57	
Anomocare convexa*	187	18		×												
Anomocare daulis	189	18		×		C 19, C 26?										
Anomocare ephori	190	18		×												35n, 35r
Anomocare flava	190	18		×								C 72				
Anomocare latelimbatum	191	18		×			C 2		C 52							35n
Anomocare lisani	191	18		×												35q
Anomocare megalurus	192	18		×										C 37		35n
Anomocare minus	192	19		×			C 9									35n, 36e, 36h
Anomocare minus var		19		×												35n, 36e
Anomocare ? nereis	193	18		×								C 69, C 72				
Anomocare subquadratum	194	18		×			C 7									35n
Anomocare sp. undt	194			×						C 77						
Anomocare various spp. undt.	194	19		×	×	C 30	C 5, C 8, C 64, C 1, C 2, C 4	C 46								
Anomocarella albion	195	20		×											C 57	
Anomocarella baucis	196	20			×			C 36								
Anomocarella bergioni	197	19			×				C 33a							
Anomocarella bigsbyi	198	21		×									C 71			
Anomocarella biston	198	21		×			C 2									
Anomocarella butes	199	19		×			C 5		C 52							
Anomocarella chinensis	200	20		×			C 1, C 2, C 4, C 62								C 57	35n, 35r, 36g
Anomocarella comus	201	19		×									C 71			
Anomocarella hermias	202	20		×												35n
Anomocarella irma	202	19		×						C 77						
Anomocarella macar	203	20		×												35n
Anomocarella smithi*	203	19		×												
Anomocarella speciosa†	205	20		×												
Anomocarella subrugosa	205	19		×			C 7									
Anomocarella tatian	206	21		×		C 23										
Anomocarella temenus	206	20		×		C 22	C 10									35n, 35r
Anomocarella tenes	207	21		×		C 28										
Anomocarella thraso‡	208	19		×			C 7									
Anomocarella toxeus	208	19		×		C 28										
Anomocarella trogus	209	19		×		C 25										
Anomocarella tutia	209	19		×		C 19	C 12									

*Occurs in 90 x, Middle Cambrian, Coosa Valley, Alabama, and is introduced for comparison.

†Occurs at Wang-tschuang, Shan-tung, China. ‡On rock with *Inouyia titiana*.

NOTE.—The column "Near Chön-p'ing-hién" is omitted in this page, as the species recorded in the first column were not collected in that locality.

General Stratigraphic and Geographic Position of the Cambrian Faunas of China—Continued.

Name.	Page.	Plates.	Stratigraphic position.			General geographic position.								
			Lower Cambrian.	Middle Cambrian.	Upper Cambrian.	Near Ch'ang-hia.	Near Yen-chuang.	Near Ch'au-mi-tién.	Near Tsi-nan.	Near Fang-lau-chön.	Near Tung-yü.	Near Chön-p'ing-hién.	Near Kao-kia-p'u.	Tschang-hsing-tau Island.
TRILOBITA—Continued.														
Anomocarella undata	210	21	....	×	....	.....	.....	.....	.....	.....	C 71	.....	.....	.....
Coosia ? bianos	210	21	.....	.....	×	.....	C 64	.....	.....	.....	.....	.....	.....	.....
Coosia carme	211	21	.....	.....	×	.....	.....	C 38	.....	.....	.....	.....	.....	.....
Coosia ? daunus	211	21	....	×	....	.....	C 2	.....	.....	.....	.....	.....	.....	.....
Coosia decelus	212	21	....	×	....	.....	C 9	.....	.....	.....	.....	.....	.....	.....
Coosia robusta*	213	21	....	×	....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Coosia superba†	213	21	....	×	....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Dolichometopus alceste	215	22	....	×	....	.....	C 1, C 4	.....	.....	.....	.....	.....	.....	.....
Dolichometopus deois	216	21, 22	....	×	....	C 19	C 1, C 2, C 4	.....	.....	.....	.....	.....	C 57	35o, 35p, 35r
Dolichometopus derceto	217	22	....	×	....	.....	C 1, C 2	.....	.....	.....	.....	.....	.....	.....
Dolichometopus dirce	218	22	....	×	....	C 24	.....	.....	.....	.....	.....	.....	.....	.....
Dolichometopus hyrie	218	22	....	×	....	.....	.....	.....	.....	C 69	.....	.....	.....	.....
Dolichometopus ? sp	.....	.....	.....	×	.....	.....	C 5	.....	.....	.....	.....	.....	.....	.....
Hysterolenus ? spp. undt	219	22, 23	.....	.....	×	.....	.....	C 38	C 56	.....	.....	.....	.....	.....
Bathyuriscus manchuriensis	219	23	....	×	....	.....	.....	.....	.....	.....	.....	.....	.....	35o, 36g, 36h
Asaphiscus iddingsi	221	23	....	×	....	.....	.....	.....	.....	.....	.....	.....	.....	35r, 36e
Illænurus canens	222	23	.....	.....	×	.....	.....	C 34, C 38, C 41, C 42	C 54	.....	.....	.....	.....	.....
Illænurus ceres	223	23	.....	.....	×	.....	.....	C 38	.....	.....	.....	.....	.....	.....
Illænurus dictys	224	23	.....	.....	×	.....	.....	.....	C 56	.....	.....	.....	.....	.....
OSTRACODA.														
Aluta bergeroni	225	23	....	×	....	.....	.....	.....	.....	.....	.....	C 32	.....	.....
Aluta enyo	225	23	....	×	....	.....	.....	.....	.....	.....	.....	C 32	.....	.....
Aluta eris	226	23	....	×	....	.....	.....	.....	.....	.....	.....	C 32	.....	.....
Aluta fragilis	226	23	....	×	....	.....	.....	.....	.....	.....	.....	C 32	.....	.....
Aluta sterope	227	23	....	×	....	.....	.....	.....	.....	.....	.....	C 32	.....	.....
Aluta woodi	227	23	....	×	....	.....	.....	.....	.....	.....	.....	C 32	.....	.....

*Occurs in 107, Middle Cambrian, Alabama, and is introduced for comparison.
†Occurs in 91, Middle Cambrian, Alabama, and is introduced for comparison.
NOTE.—The columns "Near Sin-t'ai-hién," "Near Wu-t'ai-hién," and "Near Ting-hiang-hién" are omitted in this page, as the species recorded in the first column were not collected in those localities.

RELATIONS OF THE FAUNA TO TYPICAL STRATIGRAPHIC SECTION.

In order to avoid the repetition of the lists of species from the various localities, a list of localities with the species occurring in each is given [pp. 15–28]. In the following stratigraphic sections the numbers designating the localities will be inserted so that the student may, if he desires to learn just which species occur in a given locality and position in the section, refer to the list under the locality number. In some instances it is not practicable from the known stratigraphic and paleontologic data to assign the exact horizon. In such cases an interrogation mark is placed before the locality number.

SECTIONS IN SHAN-TUNG.

The following sections are copied from vol. 1, part 1, Research in China,[1] and in addition the locality numbers of the fossils are inserted.

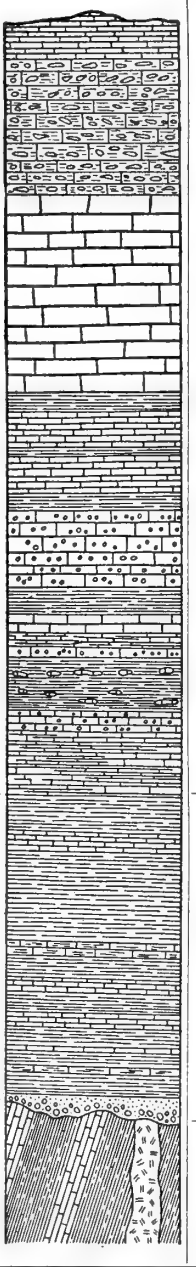
				Locality numbers.	Feet.	Meters.	Present land surface.
Sinian.	Ordovician.	Tsi-nan dolomite.	€Ot		1,800	550	Dolomitic limestone, dark gray and liver-brown colors.
					300	90	Shaly gray limestones and shales, buff crystalline dolomite, and thin white limestone.
	Cambrian.	Ch'au-mi-tién limestone.	€cm	36, 45, 47, 50, 67, 68. / 34, 38, 41, 42, 49.	600	180	Blue-gray limestone, conglomeritic at various horizons.
		Ku-shan shale.	€k		50	15	Green shale and slabby limestone.
		Ch'ang-hia limestone.	€ch	22, 24, 25, 26. 19. 18, 21, 35, 46. 30, 51. 29, 48. 23. 28.	500	150	Gray limestone mottled with ocher. Dark gray oolitic limestone. Olive-gray oolitic limestone.
		Man-t'o shales.	€m	17. 20. 31. 15, 16, 27.	500	150	Brown shale with thin gray limestones. Buff and gray shales with gray and buff earthy limestone and black slabby limestone.
T'ai-shan.	Archean.	T'ai-shan complex.	Ar t				Schists and gneisses with intruded granite, syenite, etc.
				Totals.....	3,750	1,135	

FIG. 1.—SECTION OF THE SINIAN SYSTEM IN THE CH'ANG-HIA DISTRICT, SHAN-TUNG.

[1] Willis and Blackwelder, 1907.

					Locality numbers.	Feet.	Meters.	Present land surface.
Sinian.	Carb.	Po-shan series.	Cp			150	45	Coal-bearing shales, etc.
		-Unconformity-						
	Ordovician.	Tsi-nan dolomite.	€Ot			2,500	760	Dolomitic limestone, liver-brown, blue-gray, and purplish colors.
						300	90	Ash-gray earthy limestone, partly shaly.
	Cambrian.	Kiu-lung group.	€kl		64. 11, 33a. 61. 6. 12, 13, 40, 62. 1, 2, 4, 10, 57. 5, 7, 9, 52, 63.	800	245	Blue-gray limestone. Green shales, limestones, and limestone nodules. Oolitic dark limestone
		Man-t'o shales.	€m		3. 60.	575	175	Brown shales and limestones. Maroon and yellow shales. Buff shales and earthy limestones.
		-Unconformity-						
T'ai-shan.	Archean.	T'ai-shan complex.	Ar t					Gneiss, schists, and granite.
					Totals.....	4,375	1,315	

FIG. 2.—SECTION OF THE SINIAN SYSTEM IN THE SIN-T'AI DISTRICT, SHAN-TUNG.



			Locality numbers.	Feet.	Meters.	Present land surface.
Cambro-Ordovician.	Ki-chóu limestones.	€Ok	74.	20+	6+	Dense blue limestone.
			73.	75	23	Ocherous, gray, dense, conglomeritic limestone.
			77.	110	33	Massive ocherous gray limestone.
			37, 72.	65	20	Brown and gray shales and thin-bedded limestone.
			71.	45	14	Massive gray oolitic limestone.
				15	4.5	Gray shales.
				9	3	Gray crystalline limestone.
				8	2.5	Gray calcareous shale.
				5	1.5	Oolitic limestone.
			69.	30	9	Gray and buff shales with limestone nodules.
			70.	12	3.5	Hard brown-gray oolitic limestone.
			75	35	10.5	Slabby buff limestone, dense and hard.
	Man-t'o shales.	€m		80	25	Red shales with thin reddish limestones.
				40	12.5	Red shale and argillaceous limestone, with thin yellow limestones.
				30	9	Red shale and thin limestone.
				4	1.3	Argillaceous yellow limestone.
				12	3.5	Red calcareous shale.
				3 to 15	1 to 5	Red sandstone and conglomerate.
Algonkian.	Hu-t'o system.	Ah		610+	180+	Purple argillites; siliceous limestones and dikes of greenstone.

FIG. 3.—PARTIAL SECTION OF THE SINIAN SYSTEM SOUTH OF TUNG-YÜ, SHAN-SI.

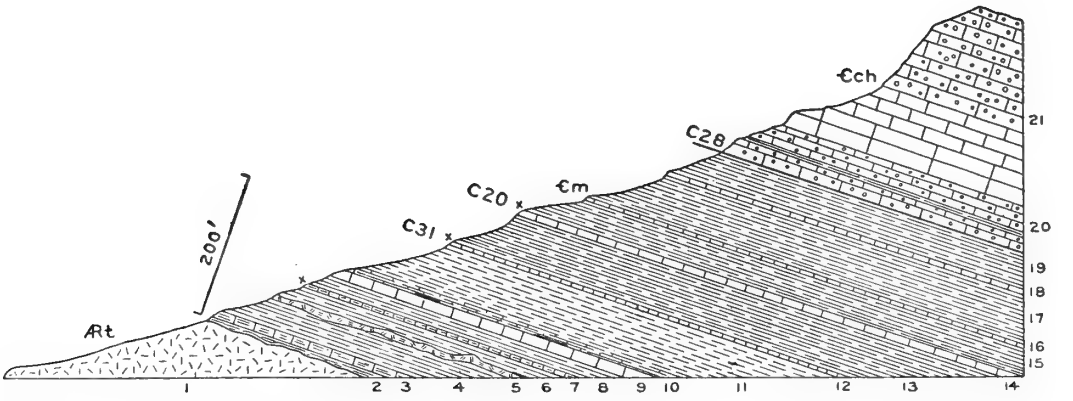


FIG. 4 (Blackwelder).—Ch'ang-hia, Shan-tung. Section of Cambrian strata in the north side of Man-t'o butte. 1 = red granite; 2 = soft yellow shales; 3 = buff earthy limestone; 4 = gray and buff calcareous shales; 5 = syenite-porphyry sheet; 6 = greenish shale; 7 = earthy limestone; 8 = maroon shale; 9 = buff earthy limestone; 10 = white calcareous shale; 11 = red shale; 12 = olive-gray limestone; 13 = dark shales; 14 = gray limestone; 15 = maroon shale; 16 = gray limestone; 17 = brown and gray shales; 18 = gray limestone; 19 = brown shale; 20 = thin-bedded, dark oolite and greenish shale; 21 = gray limestone with black oolitic bodies. This scale of thickness is indicated in feet.

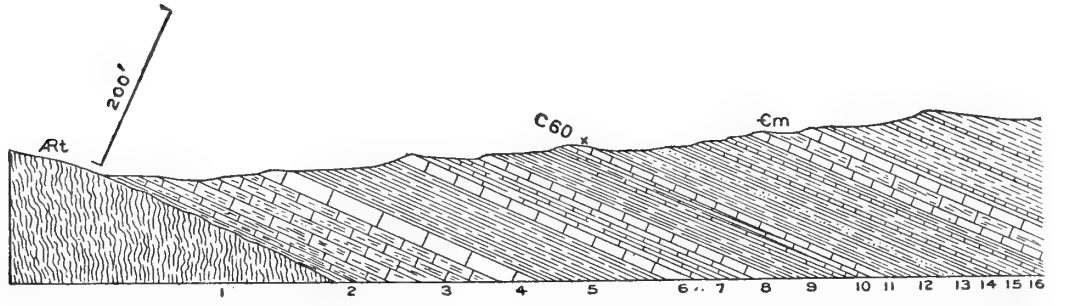


FIG. 5 (Blackwelder).—Yen-chuang, Shan-tung. Section of Cambrian strata in the western part of the Kiu-lung-shan. 1 = gray gneiss; 2 = bright green shale; 3 = gray earthy limestone; 4 = dense blue-black limestone; 5 = brown and yellow shale; 6 = blue-gray limestone; 7 = shaly gray limestone; 8 = dense blue-black limestone; 9 = yellow shale; 10 = gray limestone and shale; 11 = slaty black limestone; 12 = chocolate slate; 13 = brown shaly sandstone; 14 = yellow shale; 15 = buff earthy limestone; 16 = red shale. (Section continued in fig. 6.)

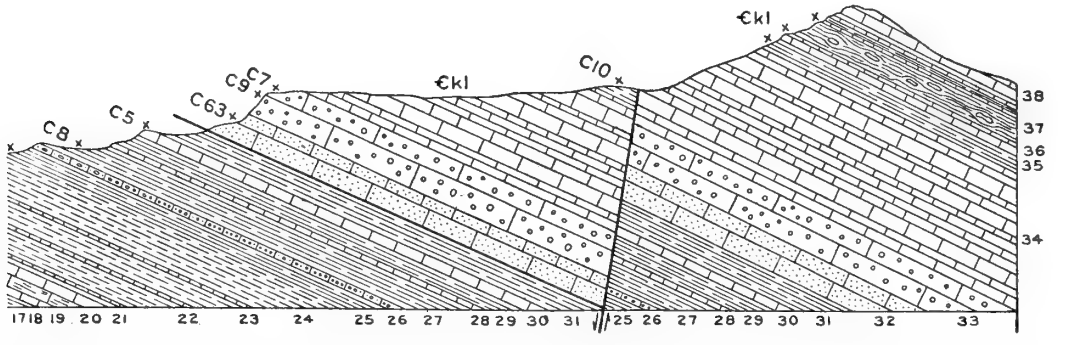


FIG. 6.—17 = black limestone; 18 = yellow shale; 19 = purple-gray limestone; 20 = gray limestone; 21 = yellow shale and thin limestone; 22 = red shale and thin limestone; 23 = green-gray limestone; 24 = red and yellow shale; 25 = maroon shale; 26 = greenish conglomeritic limestone; 27 = brown shale; 28 = buff earthy limestone; 29 = olive-green shale; 30 = cross-bedded green-gray limestone; 31 = olive shale; 32 = gray sandy limestone; 33 = hard dark oolite; 34 = light and dark gray limestone; 35 = green shale; 36 = dense gray limestone; 37 = green nodular shale and thin limestone; 38 = massive dark limestone. The scale of thickness of figures 5 and 6 is indicated in feet.

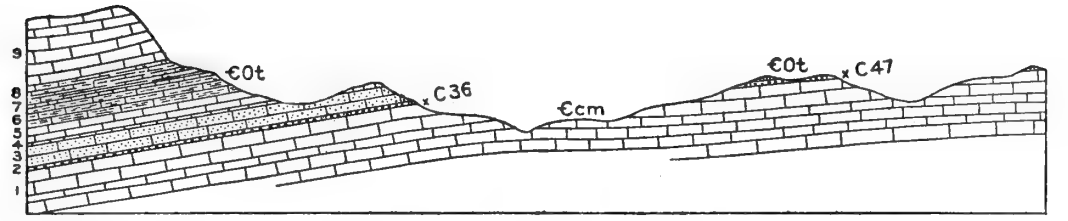


FIG. 7 (Blackwelder).—Ch'au-mi-tién, Shan-tung. Section of Upper Cambrian and Lower Ordovician strata in the ridge east of the village. 1 = dense blue-gray limestone; 2 = conglomeritic limestone; 3 = sandy yellow dolomite; 4 = white earthy limestone; 5 = buff crystalline dolomite; 6 = shaly gray limestone; 7 = blue-gray limestone; 8 = slabby yellow limestone; 9 = dense brown limestone.

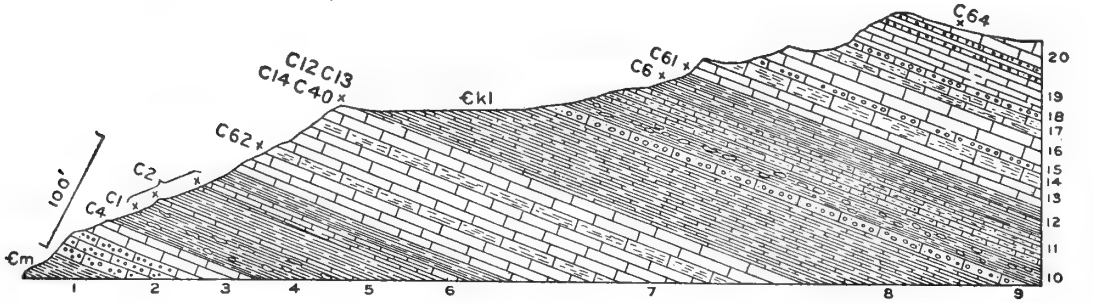


FIG. 8 (Blackwelder).—Yen-chuang, Shan-tung. Section of Kiu-lung formation in Kiu-lung-shan. 1 = Man-t'o shales; 2 = dark limestone, partly oolitic; 3 = dense gray limestone; 4 = nodular green shale; 5 = dense gray limestone; 6 = gray shale and slabby limestone; 7 = thin-bedded dense gray limestone; 8 = green calcareous shale; 9 = conglomeritic limestone; 10 = nodular green shale; 11 = slabby blue limestone; 12 = shaly limestone and gray shale; 13 = black limestone; 14 = slaty gray limestone; 15 = conglomeritic limestone; 16 = massive gray limestone; 17 = thin-bedded gray limestone; 18 = red conglomeritic limestone; 19 = dark gray limestone, locally conglomeritic; 20 = massive gray limestone.

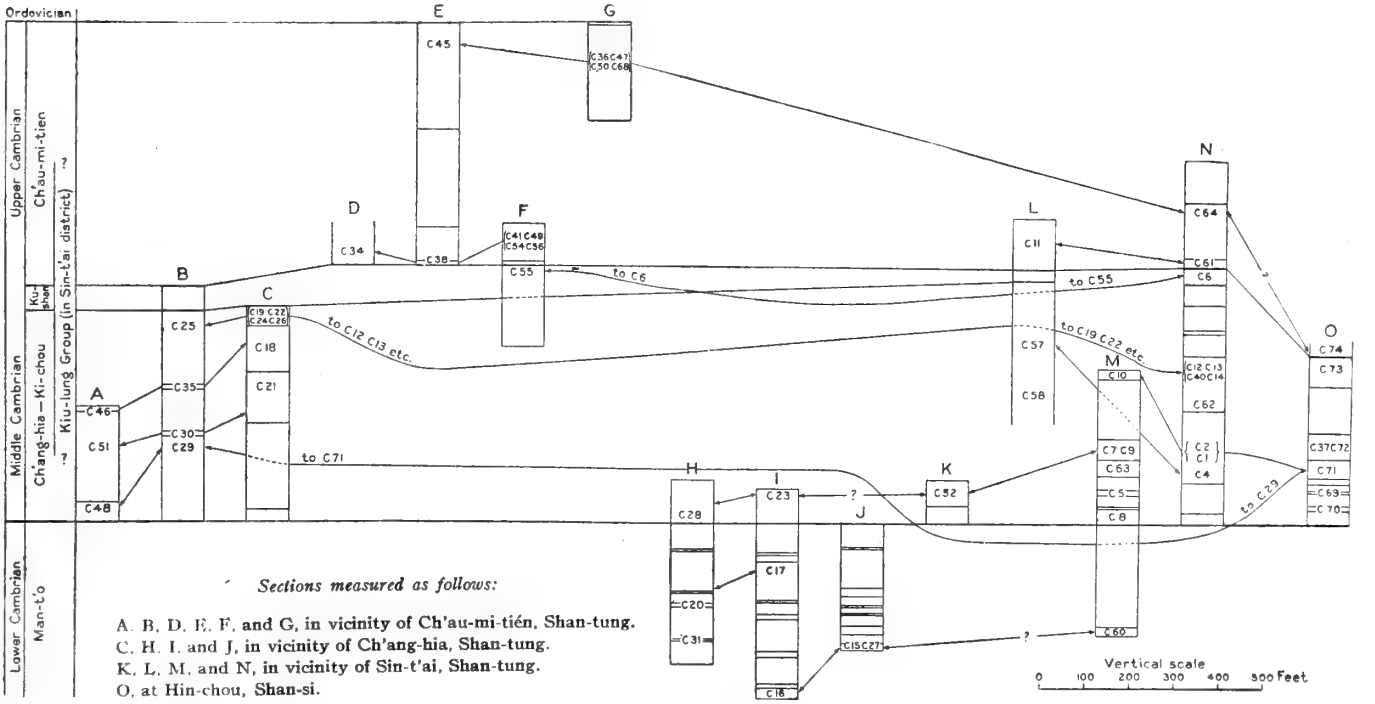


FIG. 9.—Correlation Table of the Fossiliferous Sections measured by Professors Willis and Blackwelder, showing Stratigraphic Positions of the Localities.

The assembling of the various geologic sections for the purpose of correlating them and their contained faunas led to the construction of fig. 9, on page 45, in which each section is assigned its approximate position in relation to the other sections and to a theoretically entire section. The various finds of fossils are given the same locality number as in the sections already described and in the list of localities [pp. 15–27].

SECTION IN MANCHURIA.

The following section was measured by Prof. Joseph P. Iddings on the island of Tschang-hsing-tau, Province of Liau-tung, Manchuria. Read from the top downward:

	Feet.
Massive dark gray limestone, in places mottled	200
About 500 feet of thinly bedded nodular limestone and shale. Hard and upturned, with occasional signs of trilobites. Locality 36*f* is in the upper portion of this belt	500
About 300 feet of massive limestone, in places oolitic. Locality 36*j*	300
20 feet of shale followed by thinly bedded limestone. Locality 35*q*	20
Huge concretions resembling corals—4 to 6 feet in diameter in thin buff shale. Locality 36*i*	4–5
More abundant shale, less limestone and green, dark gray, and brownish shales with thin layers of nodular limestone. Locality 35*p*	200
The exact connection is not shown of localities 35*n*, 35*r*, 36*c*, and 36*e*: green and purple shales	
White quartzitic sandstone in low cliffs, only narrow belt exposed	
Total	1,225

Notes on Horizon of Collections.

Localities 35*n*, 35*r*, 36*c*, 36*d*, and 36*e* are very nearly the same horizon, being located above a low bluff, 10 feet high, with nearly horizontal strata in places slightly folded and faulted. These are the lowest beds and not far above the basal.

Locality 35*p* is about 80 feet higher up in the shales and limestone.

Locality 36*h* is about 50 feet higher than No. 35*p*.

Localities 36*g* and 35*o* are back from the bluff on drainage cuts in shale about the horizon of No. 36*h*, I judge.

Locality 35*q* is about 70 feet higher up than No. 36*h*.

Locality 36*f* is the highest from which fossils were collected and is possibly 800 feet higher up than No. 36*c*.

DISCUSSION OF THE CAMBRIAN FAUNA OF CHINA.

The discussion of the fauna might be extended to include a detailed comparison of each species with forms resembling it from Cambrian formations in other parts of the world, but the illustrations on the plates show the characters of the species so well that I will leave to each investigator the decision as to whether the species of the fauna he may be considering are similar to those of the Chinese Cambrian. In the following notes only general statements and conclusions are given.

Algæ.—So far as known no true Algæ have been found, but fillings of mud cracks and annelid trails occur resembling stems of Algæ; their true character may be determined by comparison with similar recent phenomena.

Foraminifera.—The almost total absence of Foraminifera is probably due to oversight connected with hurried collecting and to the absence of favorable conditions for the presence and preservation of specimens. The one species *Globigerina ? mantoensis* [plate 1, fig. 1] is all that has been detected in the relatively large collections.

Porifera.—Only a few spicules of *Protospongia* are known. These indicate that when a favorable locality is discovered a fine representation of the sponges will be found.

Anthozoa.—One genus with one species of *Coscinocyathus* suggests the great development of the Archæocyathinæ in the Atlantic Basin fauna as found in the islands of Sardinia and Newfoundland, and the Pacific Basin fauna in the Cordilleran area of Nevada in western America. In Asia the type is known from Siberia as described by Eduard von Toll [1899].

Annelida.—A few trails are all the traces that have been found of the annelids. One of these is illustrated by plate 1, figure 5.

Brachiopoda.—Among the brachiopods none of the genera is peculiar to the Chinese Cambrian. All belong to genera found in the Middle Cambrian of western North America and northwestern Europe. The genus *Micromitra* is well developed and I have inserted on plate 1, figure 13, a photographic reproduction of a specimen from the Middle Cambrian of British Columbia, that has the pedicle and surface spines finely preserved.

Gastropoda.—The patelloid forms are represented by two genera, *Scenella* and *Matherella*, and three species, two from the Middle Cambrian (C18, C70) and one from the Upper Cambrian (C56); the cone-shaped forms by three species of the genus *Helcionella*, one of which, *Helcionella rugosa chinensis* [plate 5, fig. 8], has a dissepiment toward the apex, a feature also shown by both *H. ? ? simplex* [plate 5, fig. 11] and *H. ? clurius* [plate 5, fig. 7]. The coiled gastropods are of unusual interest, as three forms, *Matherella?* sp. undt. (C55) [plate 5, fig. 6], *Pelagiella chronus* (C1, C4, C18) [plate 5, figs. 9, 9*a–b*], and *P. willisi* (C72) [plate 5, figs. 12, 13] are from the Middle Cambrian.

Pteropoda.—The species of the genera *Hyolithes* and *Orthotheca* are of the usual Cambrian type. I have introduced on plate 6, figure 8, a reproduc-

tion from a photograph of a *Hyolithes* (*H. carinatus* Matthew) that shows the operculum in position, also the support of the fin-like arms so characteristic of recent pteropods.

Cephalopoda.—One genus and one species from a horizon 480 feet (146 m.) below the summit assigned to the Upper Cambrian are all that are known of this class. The species *Cyrtoceras cambria* (C56) [plate 6, figs. 4, 4*a–c*] is a typical example of the family Cyrtoceridæ and from its presence we are compelled to consider that there was a large and varied cephalopod fauna in the area, from which it migrated into the Sinian sea. It is a reminder of our want of data on the fauna of the Upper Cambrian and of the great harvest to be gathered by the future field-worker and student of the stratigraphic geology of Asia.

In the Ozark region of Missouri in North America Ulrich has found both the Cephalopoda and Gastropoda extensively developed at a horizon not much above that of *Cyrtoceras cambria*, if we base the correlation on the character of the trilobites in the two distant localities.

Trilobita.—The exceptional genera of the Trilobita found in China and not known to occur elsewhere are *Stephanocare* [plate 7], *Teinistion* [plate 9], *Blackwelderia* [plate 9], *Damesella* [plate 9], and *Drepanura* [plate 10]. All other genera are represented in western North America and western Europe, and there is a striking resemblance even to specific characters in many of the forms. The most noticeable omissions of American and European genera from the Chinese fauna are *Paradoxides* of the Atlantic Basin fauna and *Olenoides*, *Dikelocephalus*, and *Neolenus* of the North American fauna. The closely related genus *Dorypyge* (to *Olenoides*) is found abundantly in China, western United States, and on the island of Bornholm in northwestern Europe.

The genera *Ptychoparia*, *Conokephalina*, *Acrocephalites*, *Inouyia*, *Agraulos*, *Lisania*, *Solenopleura*, *Anomocare*, *Anomocarella*, and *Coosia* are well represented in China, western North America, southwestern United States, and northwestern Europe. *Bathyuriscus* and *Asaphiscus* are essentially Pacific Basin types. They represent the most advanced forms of the Trilobita of Middle Cambrian time and may be compared with *Asaphus* and *Bathyurus* of the Ordovician fauna.

Redlichia is an intermediate form that serves in a limited degree to connect the Mesonacidæ [Walcott, 1910*a*] and the Paradoxidæ. Its tapering glabella and elongate eye-lobes recall those of *Nevadia*, and its small pygidium that of *Holmia* and *Callavia* [see Walcott, 1910*a*, plate 44].

Many species of trilobites are represented only by fragments of the cephalon, scattered segments of the thorax, and pygidia that can only be tentatively designated as probably belonging to the same species as an associated cephalon. In some instances the cephala of otherwise distinct genera are so nearly similar that in the absence of the thorax and pygidium they would be referred to one genus. This is particularly the case among the genera of the Ptychoparidæ.

THE LARGER FAUNAL HORIZONS.

The geographic distribution and characters of the Lower, Middle, and Upper Cambrian divisions of the eastern and southern Asiatic Cambrian faunas vary to such an extent as to make it desirable to consider them separately. It seems from our present information that the Cambrian sea first transgressed the southern and southeastern sections of the continent in late Lower Cambrian time and that certain changes occurred in its distribution at intervals during the remainder of Cambrian time. The data, however, are still too limited to give more than very approximate limits to the distribution of the faunas. Extended areal mapping of the distribution of the geologic formations and faunas will be necessary before paleographic maps of eastern Asia can be made that are more than broad outlines to be changed and filled in very much as the geographic map of Africa was modified from time to time during the last half of the nineteenth century.

Lower Cambrian Fauna.—The Lower Cambrian (Man-t'o shale) *Redlichia* fauna of Shan-tung, Shan-si, Yun-nan, and northern India is, so far as known, very distinctive and confined to the Asiatic continent and Australia.

The fauna is unknown in Manchuria, although Blackwelder considered that the Yung-ning sandstone of southern Liau-tung was probably of Lower Cambrian age. [Blackwelder, 1907, p. 87.]

In this and the following lists I have combined the local lists, placing after each species the locality number, so that each species may be traced back to its local list and thus found with its immediate associates in the strata.

In Central Shan-tung the Man-t'o sandstones contain a small fauna, as follows:

Billingsella richthofeni (C 3, C 20)
Obolella asiatica (C 17, C 32′)
Helcionella rugosa chinensis (C 3)
Hyolithes delia (C 3)
Hyolithes sp. undt. (C 32′)
Redlichia chinensis (C 15, C 16, C 27)
Redlichia nobilis (C 3)
Redlichia sp. undt. (C 6)
Ptychoparia aclis (C 17, C 20, C 31)
Ptychoparia granosa (C 17)
Ptychoparia impar (C 17)
Ptychoparia ligea (C 31)
Ptychoparia (*Emmrichella*) *constricta* (C 3)
Ptychoparia (*Emmrichella*) *mantoensis* (C 20, C 31)

Of the above, *Obolella asiatica*, *Helcionella rugosa chinensis*, and *Redlichia chinensis* may be considered as characteristically Lower Cambrian. I do not know of the occurrence of the genus *Obolella* above the Lower Cambrian [Walcott, 1912, p. 588], and *Helcionella rugosa* belongs to the same fauna. *Redlichia chinensis* and *R. nobilis* have been referred to as descendent from *Olenellus* [Walcott, 1910*a*, p. 254], but I would now cite *Callavia* in place of *Olenellus*, as the latter genus appears to have left no descendants. It should also be noted that the very ancient form *Nevadia* has a tapering glabella and long eye-lobes [Walcott, 1910*a*, plate 23], which leads me to consider *Redlichia* as an example of reversion to a more primitive type in the form of the glabella. The thorax and pygidium of *Redlichia* are more like the same parts in *Wanneria* [Walcott, 1910*a*, plate 30], except for the median spines of the thoracic segments.

It is to be anticipated that the Man-t'o shale *Redlichia* fauna will be found at other localities in eastern China, but at the present writing the nearest locality is in southern China near Yun-nan [Mansuy, 1913. In press], about 1,300 miles (2,100 km.) to the southwest. At this locality *Redlichia chinensis* occurs in a shale and associated with it a new genus of trilobites allied to *Agraulos* named *Palæolenus* by Mansuy.

An interval of about 1,700 miles (2,700 km.) occurs between the Yun-nan locality of *Redlichia* and its occurrence in northern India in Spiti as the closely allied species *R. noetlingi*.[1]

In Western Australia *Redlichia* occurs in the Kimberley district. It was published as *Olenellus ? forresti* [Etheridge, Jr., MSS.] by Arthur H. Foord.[2]

In South Australia a very good specimen of the central portions of the cephalon is mentioned as *Olenellus* sp., by R. Etheridge, Jr.[3]

The distribution of *Redlichia*, of the *R. noetlingi* form, serves to demonstrate that the transgressing Lower Cambrian sea that contained the *Redlichia* fauna was confined to eastern and southeastern China and northern India. The presence of *Redlichia*-like trilobites in southern and western Australia indicates that there was direct connection between the Punjab Lower Cambrian sea of India and the shallow seas about the Australian area. There is no record pointing to a connection between the Punjab–Man-t'o sea and the Lower Cambrian seas of northern Siberia, or western North America.

Middle Cambrian Fauna.—The lower portion of the Middle Cambrian section and its contained fauna show that a marked change took place at the close of the Man-t'o shale epoch. Willis concludes that aridity and severe cold were conditions of the climate during Man-t'o shale time; that life was abundant elsewhere and with the changing of climate it developed rapidly in the seas following the Man-t'o [Willis, 1907, p. 40]. Of the rocks of the Kiu-lung group following the Man-t'o, he says:

> *Middle Sinian, Kiu-lung group.*—The Kiu-lung group of Shan-tung is a succession of limestones and shales which immediately follows the Man-t'o formation. Transition beds connect the two. Shale is a common rock in both, but in the Man-t'o it is red, whereas in the Kiu-lung it is green. Limestone is thin-bedded and subordinate in the former, in the latter it is usually massive and predominant. The Man-t'o contains a sparse Middle or Lower Cambrian fauna in its upper portion; the Kiu-lung carries very abundant faunas, which range from Middle Cambrian at the base to Upper Cambrian and possibly to lowest Ordovician at the top.

The known distribution of the limestones and shales and their contained faunas of the Middle Cambrian is outlined by Willis, also the area in which they are supposed to occur [1907, vol. 11, plate 4]. The known distribution from Manchuria on the northeast to central China, and west into northern

[1] Mem. Geol. Surv. India, n. ser., vol. 1, 1901, p. 2; also Idem., series XV, vol. VII, No. 1, 1910, p. 7.
[2] Geol. Mag., London, Dec. III, vol. VII, 1890, p. 199, plate IV, figs. 2, 2*a*–*b*.
[3] Trans. Roy. Soc. South Australia, vol. XXIX, 1905, plate XXV, fig. 1. (See Tate, vol. 15, 1892, plate 2, p. 183.)

India [Reed, 1910, p. 66], taken with the occurrence of fragments of the fauna in Siberia in the valleys of the Lena, Yenisei, and Angara [von Toll, 1899], indicates something of the extent of the Middle Cambrian sea. The larger area outlined by Willis in which Cambrian rocks are supposed to occur is probably much too small, as later rocks undoubtedly conceal large areas of the Cambrian.

The prevalence of limestones with interbedded calcareous and argillaceous shales indicates relatively shallow seas and favorable environment for the life of the sea. This inference is supported by the number of genera and species already found in the hurried collecting necessitated by the conditions of exploration met with by the Willis and Iddings parties.

In the Ch'ang-hia District the Middle Cambrian is represented in the Ch'ang-hia limestone, in the Sin-t'ai district by the lower portion of the Kiu-lung limestone, and in Shan-si by the lower 400 feet (118 m.) of the Ki-chóu limestone.

The lower portion of the Kiu-lung group lower limestone contains the following fauna:

Globigerina ? mantoensis (C 5)
Coscinocyathus elvira (C 75)
Micromitra (Paterina) labradorica orientalis (C 9)
Micromitra (Iphidella) pannula ophirensis (C 5)
Obolus damesi (C 7)
Obolus obscurus (C 63, C 75)
Lingulella (Lingulepis) eros (C 7)
Eoorthis agreste (C 28)
Eoorthis kichouensis (C 75)
Acrotreta pacifica (C 5)
Acrothele rara (C 23)
Orthotheca daulis (C 23)
Scenella ? dilatatus (C 70)
Helcionella ? ? simplex (C 70)
Redlichia finalis (C 58)
Ptychoparia impar var. (C 8)
Ptychoparia lilia (C 75)
Ptychoparia tolus (C 52)
Ptychoparia sp. (C 58)
Ptychoparia (Emmrichella) eriopia (C 23)
Ptychoparia (Emmrichella) theano (C 23)
Conokephalina maia (C 70)
Conokephalina sp. (C 70)
Inouyia abaris (C 7, C 9)
Inouyia armata (C 75)
Inouyia capax (C 70)
Inouyia divi (C 5)
Inouyia melie (C 70, C 75)
Inouyia thisbe (C 28)
Inouyia titiana (C 7)
Agraulos abrota (C 23)
Agraulos dirce (C 52)
Agraulos dolon (C 7)
Agraulos nitida (C 75)
Agraulos uta (C 75)
Agraulos vicina (C 70)
Anomocare latelimbatum (C 52)
Anomocare minus (C 9)
Anomocare sp. (C 5)
Anomocare sp. undt. (C 8)
Anomocarella butes (C 5, C 52)
Anomocarella subrugosa (C 7)
Anomocarella tatian (C 23)
Anomocarella tenes (C 28)
Anomocarella thraso (C 7)
Anomocarella toxeus (C 28)
Coosia decelus (C 9)
Dolichometopus ? sp. (C 5)
Bathyuriscus ? sp. (C 28)

Of the above fauna only three species pass into the strata above. One is *Obolus damesi*, which occurs a little higher in the limestone beneath the horizon of the Ku-shan shale, and it has a possible representative in the upper part of the Upper Cambrian. *Inouyia melie* Walcott and *I. divi* Walcott are found in the strata a little higher in the section.

The next succeeding faunal zone contains:

Protospongia chloris (C 4)
Acrothele matthewi eryx (C 4)
Acrothele rara (C 57)
Acrotreta pacifica (C 4)
Pelagiella chronus (C 4)
Hyolithes cybele (C 4)
Hyolithes ? (operculum) (C 4)
Orthotheca delphus (C 4, C 57)
Agnostus chinensis (C 4, C 57)
Agnostus kushanensis (C 57)
Dorypyge richthofeni (C 57)
Conokephalina vesta (C 69)
Inouyia inflata (C 69)
Agraulos obscura (C 69)
Lisania alala (C 4)
Anomocare alcinoe (C 57)
Anomocare nereis (C 69)
Anomocarella albion (C 4, C 57)
Anomocarella chinensis (C 4, C 57)
Dolichonetopus alceste (C 4)
Dolichometopus deois (C 4, C 57)
Dolichometopus hyrie (C 69)

This fauna is at the base of the rich *Dorypyge richthofeni* fauna and several of its species continue up into the next grouping of genera and species, which is one of the most important of the subfaunas of the Middle Cambrian of China. It includes, in the Sin-t'ai district of Shan-tung:

Protospongia chloris (C 1, C 2)
Obolus damesi (C 10)
Obolus minimus (C 1)
Obolus shansiensis ? (C 71)
Obolus (Westonia) blackwelderi (C 1, C 2)
Yorkia ? orientalis (C 71)
Acrotreta pacifica (C 1, C 2)
Acrotreta shantungensis (C 71) (? C 1)
Eoorthis sp. undt. (C 71)
Pelagiella chronus (C 1)
Hyolithes cybele (C 1, C 2)
Orthotheca cyrene dryas (C 2)
Orthotheca glabra (C 71)
Agnostus chinensis (C 1, C 2, C 71)
Dorypyge bispinosa (C 2)
Dorypyge richthofeni (C 1, C 29)
Dorypyge richthofeni lævis (C 71)
Agraulos dryas (C 29)
Inouyia divi (C 1)
Lisania agonius (C 1, C 2)
Solenopleura pauperata (C 71)
Menocephalus sp. undt. (C 10)
Anomocare latelimbatum (C 2)
Anomocarella albion (C 1, C 2)
Anomocarella bigsbyi (C 71)
Anomocarella biston (C 2)
Anomocarella chinensis (C 1, C 2)
Anomocarella comus (C 71)
Anomocarella temenus (C 10)
Anomocarella undata (C 71)
Coosia ? daunus (C 2)
Ptychoparia sp. undt. (C 48)
Crepicephalus damia (C 71)
Crepicephalus magnus (C 48)
Lonchocephalus tellus (C 2)
Dolichometopus alceste (C 1)
Dolichometopus deois (C 1, C 2)
Dolichometopus derceto (C 1, C 2)

In the Ch'ang-hia district, at a supposed slightly higher horizon, the following genera and species occur:

Obolus chinensis (C 62)
Obolus shansiensis (C 37)
Lingulella (Lingulepis ?) sp. undt. (C 72)
Acrotreta lisani (C 22)
Acrotreta cf. *pacifica* (C 24)
Acrotreta shantungensis (C 37, C 62)
Eoorthis sp. undt. (C 26)
Pelagiella willisi (C 72)
Hyolithes cybele (C 22, C 62)
Orthotheca glabra (C 72)
Agnostus sp. undt. (C 24)
Dorypyge richthofeni (C 19, C 24)
Dorypyge richthofeni lævis (C 72)
Damesella brevicaudata (C 19)
Conokephalina sp. undt. (C 72)
Crepicephalus damia (C 26)
Crepicephalus cf. *magnus* (C 25)
Inouyia divi (C 24)
Lisania alala (C 22)
Lisania belenus (C 19)
Lisania bura (C 22)
Solenopleura agno (C 25)
Menocephalus abderus (C 19)
Menocephalus acanthus (C 22)
Menocephalus admeta (C 22)
Levisia agenor (C 25)
Anomocare ? daulis (C 19, C 26)
Anomocare flava (C 72)
Anomocare megalurus (C 37)
Anomocare ? nereis (C 72)

Anomocare sp. (C 25)
Anomocarella chinensis (C 62)
Anomocarella temenus (C 22)
Anomocarella trogus (C 25)
Anomocarella tutia (C 19)
Dolichometopus deois (C 19)
Dolichometopus dirce (C 24)

Above this horizon the fauna again changes. The trilobitic genera *Dorypyge*, *Dolichometopus*, and *Solenopleura* drop out and the genera *Damesella*, *Blackwelderia*, and *Teinistion* foreshadow the rich and in many respects unique fauna of the Ku-shan shale.

This fauna in the upper horizon of the Ch'ang-hia limestone in Shan-tung contains the following:

Acrotreta pacifica (C 12)
Teinistion alcon (C 12)
Blackwelderia alastor (C 12)
Blackwelderia cilix (C 73)
Damesella bellagranulata (C 13)
Damesella blackwelderi (C 12, C 13, C 14, C 40)
Pterocephalus asiaticus (C 12)
Inouyia acalle (C 12)
Inouyia ? regularis (C 73)
Lisania ajax (C 12, C 40)
Anomocarella tutia (C 12)

In the Ku-shan shaly beds, just above the beds containing the preceding, the following occur:

Obolus (Westonia) blackwelderi (C 6)
Dicellomus parvus (C 6)
Acrothele ? minuta (C 6)
Straparollina sp. undt. (C 55)
Agnostus douvillei (C 6, C 55)
Redlichia sp. undt. (C 6)
Stephanocare ? monkei (C 6)
Stephanocare richthofeni (C 6, C 55)
Stephanocare sinensis (C 6)
Stephanocare ? sp. undt. (C 6)
Blackwelderia cilix (C 55)
Blackwelderia sinensis (C 6)
Drepanura ketteleri (C 6, C 55)
Drepanura premesnili (C 6, C 55)
Ptychoparia (Emmrichella) bromus (C 6)
Liostracina krausei (C 6)
Shantungia spinifera (C 6)

This assemblage of genera and species forms a varied and unique fauna, which has little in common with the faunas above and below it in the strata. It is a local phase of the Cambrian fauna corresponding somewhat to one of the subdivisions of the Middle Cambrian fauna of western North America as represented by the fauna of the Stephen formation of British Columbia [Walcott, 1908*c*, pp. 243–244, plates I–IV; 1908*e*, pp. 210, 211]. In each there are trilobites with large pygidia. *Damesella* and *Neolenus*, respectively, are typical examples, and there are several genera not found at other horizons or in other countries.

The Middle Cambrian fauna of China, like that of western North America, is marked by the absence of the genus *Paradoxides*. Fortunately there are other genera that serve to connect the *Paradoxides* fauna of the Atlantic Province with the *Dorypyge* fauna of the Pacific Province. *Dorypyge* is associated with *Paradoxides*, *Solenopleura*, *Anomocare*, etc., in northwestern Europe [Grönwall, 1902, plates 3, 4]. In China, *Dorypyge* [see Locality 35*r*, p. 26] is found with *Solenopleura*, *Anomocare*, *Dolichometopus*, and other genera associated with *Paradoxides* in the Atlantic Province. The order of stratigraphic succession of the *Dorypyge* fauna is essentially the same in the two provinces.

The Middle Cambrian fauna, like that of western North America, is much larger and more abundant than that of the Upper Cambrian. This was due in a considerable degree to the usually favorable conditions existing on account of the great variety of habitat afforded by the seas of the period. The advancing and deepening Middle Cambrian sea forced the local faunas to change their habitat from time to time and they had either to adjust themselves to the new conditions and habitat or to perish. Local isolation for long periods led to the development of new forms, and these, when the barriers were removed, contested and competed for their position and existence with other faunas until, by a process of elimination of those least fit to survive, the development was hastened of a large and varied fauna. By the close of the Middle Cambrian more stable conditions prevailed and the era of rapid evolution was checked until, under the impulse of new conditions of environment and accumulated tendency to change following the close of the Cambrian, a great evolution of new forms of life began.

Upper Cambrian Fauna.—The geographic distribution of the formations containing this fauna is the same as for the Middle Cambrian, so far as now known. In the Sin-t'ai district the upper shale (Ku-shan?) and its fauna serve to form an upper horizon to the Middle Cambrian. The first fauna above the Ku-shan shale occurs in a limestone and, although only 10 feet (3 m.) higher in the section, is entirely distinct from that of the Ku-shan shale. In includes the following:

Billingsella pumpellyi (C61)
Proampyx burea (C61)
Pterocephalus busiris (C61)
Chuangia batia (C11, C33*a*, C61)
Chuangia fragmenta (C61)
Chuangia nitida (C11)
Ptychaspis baubo (C61)
Anomocarella bergioni (C33*a*)

Sixty feet (18 m.) above the Ku-shan shale the fauna includes:

Chuangia batia (C11, C33*a*) *Chuangia nitida* (C11) *Anomocarella bergioni* (C33*a*)

In the Ch'ang-hia district, at about 100 to 120 feet (30 to 36 m.) above the base of the formation, the fauna is relatively large and varied. It includes the following:

Obolus matinalis ? (C54)
Obolus (*Westonia*) sp. undt. (C56)
Discinopsis sulcatus (C56)
Eoorthis pagoda (C54, C56)
Syntrophia orthia (C54, C56)
Scenella sp. undt. (C56)
Matherella circe (C56)
Pelagiella pagoda (C56)
Orthotheca sp. undt. (C56)
Cyrtoceras cambria (C56)
Agnostus sp. undt. (C34)
Conokephalina belus (C56)
Conokephalina dryope (C56)
Lisania sp. undt. (C41)
Pterocephalus busiris (C54)
Pagodia bia (C56)
Pagodia dolon (C41)
Pagodia lotos (C56)
Pagodia macedo (C34)
Menocephalus? depressus (C49, C56)
Ptychaspis brizo (C38)
Ptychaspis cadmus (C41)
Ptychaspis calchas (C41)
Ptychaspis calyce (C42)
Ptychaspis campe (C42)
Ptychaspis ceto (C34, C38, C54, C56)
Ptychaspis sp. undt. (C54)
Coosia carme (C38)

Hysterolenus sp. (C38)
Hysterolenus ? (C56)
Illænurus canens (C34, C38, C54)
Illænurus ceres (C38)
Illænurus dictys (C56)
Illænurus sp. undt. (C 54)

The fauna of the upper portion of the Ch'au-mi-tién limestone is best represented from 50 to 75 feet (15 to 23 m.) below the summit of the limestone. It contains a characteristic grouping of genera and species, as follows:

Obolus damesi (C64)
Eoorthis doris (C64)
Eoorthis kayseri (C64, C68, C74)
Eoorthis linnarssoni (C64)
Huenella orientalis (C64)
Syntrophia orthia (C64)
Billingsella pumpellyi (C36)
Pelagiella clytia (C47)
Hyolithes daphnis (C64)
Orthotheca cyrene (C47, C64)
Coosia ? bianos (C64)
Anomocare sp. (C64)
Anomocarella baucis (C36)
Anomocarella? sp. undt. (C68)
Ptychaspis acamus (C45)
Ptychaspis baubo (C64)
Ptychaspis bella (C74)
Ptychaspis cacus (C64)
Ptychaspis callisto (C64)
Ptychaspis calyce (C64)
Ptychaspis ceto (C45, C64)
Ptychaspis sp. undt. (C64)
Ptychaspis sp. (C47, C50)
Chuangia batia (C64)
Chuangia nais (C64)
Solenopleura beroe (C64)
Illænurus sp. undt. (C45)

The stratigraphic range of the genera of the Upper Cambrian in China is shown by the following table. Of the 27 genera in the table all occur in the Cambrian of North America, with the possible exception of *Chuangia*.

Class and genus.	Lower Cambrian.	Middle Cambrian.	Upper Cambrian.		
			Base.	Central.	Near summit.
Brachiopoda:					
Obolus		×		×	×
Discinopsis				×	
Billingsella	×		×		×
Eoorthis		×		×	×
Huenella					×
Syntrophia				×	×
Gastropoda:					
Scenella		×		×	
Straparollina		×		×	
Pelagiella		×		×	×
Pteropoda:					
Hyolithes	×	×		×	×
Orthotheca		×		×	×
Cephalopoda:					
Cyrtoceras				×	

Class and genus.	Lower Cambrian.	Middle Cambrian.	Upper Cambrian.		
			Base.	Central.	Near summit.
Trilobita:					
Agnostus		×		×	
Conokephalina		×		×	
Proampyx			×		
Pterocephalus		×	×	×	
Pagodia		×			×
Lisania		×		×	
Solenopleura		×			×
Chuangia		×	×		×
Menocephalus		×		×	
Ptychaspis		×	×	×	×
Anomocare					×
Anomocarella		×	×		×
Coosia		×		×	
Hysterolenus				×	
Illænurus				×	×
Total number	2	18	6	19	15

The Upper Cambrian fauna of China is characterized by genera that are well developed in the same fauna in North America. The genus *Ptychaspis* is particularly prominent in species and numbers in the Upper Cambrian both in China and America. *Illænurus* is represented by four species in the central portion of the Ch'au-mi-tién limestone and one at the upper horizon. In America it is found in the limestones referred to the Upper Cambrian where it has a considerable vertical range[1] and wide geographic distribution.

[1]Walcott, 1908*e*, pp. 175, 177, 192, 204, 205.

The absence of a true *Dikelocephalus* is to be noted, as the genus is associated with *Ptychaspis* and *Illænurus* in the Upper Cambrian of the interior portions of the North American continent. It is not certainly known from the western or Cordilleran region.

FAUNAL PROVINCES OF THE CAMBRIAN IN ASIA.

Mr. F. R. Cowper Reed [1910, pp. 62–70] has given a summary of the geographic distribution of the Cambrian formations in Asia, and called attention to the probability that Frech's "Pacific Zoögeographical province" would need to be subdivided [Reed, 1910, p. 63]. I find that while the Cambrian fauna of the Pacific Province of eastern Asia has a strong generic relationship with that of the Rocky Mountain area of eastern North America, yet in each area there is a group of genera that are not found in the fauna of the other area. On this account it seems best to consider the Rocky Mountain Province[1] as a subprovince distinct from the Middle and Upper Cambrian of the eastern Asian subprovince of the same periods. The Lower Cambrian *Redlichia* fauna of Asia is so distinct that there is no probability of its having lived in the same province with the Mesonacidæ fauna of North America. The North American Middle Cambrian fauna is distinctive in having the brachiopod genus *Nisusia* Walcott and the trilobitic genera *Karlia* Walcott, *Ogygopsis* Walcott, *Burlingia* Walcott, *Zacanthoides* Walcott, *Oryctocara* Walcott, and *Neolenus* Matthew.

The Chinese Middle Cambrian fauna has in its upper portion a few genera not known from the North American fauna. These include, as described in this memoir, *Damesella*, *Blackwelderia*, *Teinistion*, *Stephanocare*, *Drepanura*, *Shantungia*, and *Liostracina*. The fauna containing the genera mentioned, like that of the genera listed above from North America, belongs to a local fauna that did not obtain a distribution outside of the limited area in which it lived. It could not in either case have developed in the communicating seas in which the greater world-wide and typical fauna of the Middle Cambrian lived.

The Upper Cambrian fauna of China, as now known, is essentially the same in its generic aspect with that of western North America. This is discussed in the section on The Larger Faunal Horizons [pp. 49–56].

A comparison of the faunas in the four local areas of the Cambrian in Asia shows the presence of three provinces:

1. Shan-tung Province (including Manchuria and Shan-si subprovince).
2. Punjab Province (including Yun-nan area).
3. Siberian Province.

[1]Walcott, 1891*b*, pp. 313–330, plate 1.

The largest fauna is that of the Shan-tung subprovince. This includes the Cambrian area in Shan-tung and its extension northward in Manchuria. The species common to the Shan-tung and Manchuria areas are:

Protospongia chloris
Micromitra (Iphidella) pannula ophirensis
Obolus chinensis
Obolus damesi
Obolus shansiensis
Acrothele matthewi eryx
Acrotreta pacifica
Acrotreta shantungensis
Hyolithes cybele
Orthotheca cyrene
Orthotheca delphus
Agnostus chinensis
Agnostus douvillei
Dorypyge richthofeni
Teinistion typicalis
Stephanocare sinensis
Blackwelderia sinensis
Damesella brevicaudata
Drepanura premesnili
Liostracina krausei
Shantungia spinifera
Solenopleura agno
Solenopleura beroe
Anomocare megalurus
Anomocare minus
Anomocare subquadratum
Anomocarella chinensis
Anomocarella temenus
Dolichometopus deois

The Shan-si subprovince[1] has five species of Middle Cambrian fossils and one Upper Cambrian species common to it and to the southern Shan-tung Province area in Shan-tung, as follows:

LOWER CH'ANG-HIA FAUNA.—*Obolus obscurus, Obolus shansiensis, Acrotreta shantungensis, Agnostus chinensis, Crepicephalus damia.*
CH'AU-MI-TIÉN FAUNA.—*Plectorthis kayseri.*

With the Manchurian extensions of the Shan-tung Province the Shan-si fauna has five species in common, as follows:

SHAN-SI AND MANCHURIA.—*Obolus shansiensis, Acrotreta shantungensis, Orthotheca glabra, Agnostus chinensis.*

In southern China, as previously stated [p. 50], there is no record pointing to a connection between the Punjab–Man-t'o sea and the Lower Cambrian seas of northern Siberia, or western North America.

In Middle Cambrian time, as stated by Reed, the Spiti fauna is more strongly related to that of western North America than to any other Middle Cambrian fauna [Reed, 1910, pp. 64 and 65]. So far as China is concerned, the northern Indian fauna is that of another faunal province.

The Cambrian fauna of the Siberian Province includes species that are referred to the Middle Cambrian fauna, and a few that may be tentatively assigned to the Lower Cambrian. Doctor von Toll has identified a number of genera of the Archæocyathinæ [von Toll, 1899, p. 53] that may occur in the upper portion of the Lower Cambrian terrane. The one species of *Coscinocyathus* from China, *C. elvira* Walcott, occurs in the Middle Cambrian, but this is a very small form and may have been a survival in Middle Cambrian time of the large Archæocyathinæ fauna of late Lower Cambrian time. In North America the Archæocyathinæ flourished most abundantly in late Lower Cambrian time [Walcott, 1891*a*, pp. 599–602, plates 50–55] on both the eastern and western sides of the continent. Von Toll lists from the *Archæocyathus* limestones of Torgoschino [von Toll, 1899, p. 53], in addition to sixteen species of the Archæocyathinæ, two species of trilobites, *Dorypyge*

[1]The geographic distribution of the Shan-tung, Manchuria, and Shan-si Cambrian rocks is shown by Willis [1907, vol. II, plate 4].

slatkowskii Schmidt and *Solenopleura ? sibirica* Schmidt. The species of *Dorypyge* is quite unlike *Dorypyge richthofeni* Dames from the Middle Cambrian of Shan-tung, and the *Solenopleura ? sibirica* has no representative in the Chinese Cambrian fauna. He also places *Microdiscus lenaicus* von Toll in the Lower Cambrian along with the Torgoschino limestone fauna [von Toll, 1899, p. 54]. I see no objection to this arrangement, but I would place the fauna as of late Lower Cambrian age. This would bring it in point of time in correlation with the *Redlichia* fauna of the Shan-tung and Punjab provinces. The Siberian fauna, however, is that of the Lower Cambrian of Australia, Sardinia, and North America. This leads to the conclusion that the Siberian province was quite distinct in Lower Cambrian time from the Shan-tung and Punjab provinces, and that, as von Toll so well states, "The Sinio-Siberian sea stood on the one hand in connection with the Pacific-American and on the other with the Atlantic-European." [Von Toll, 1899, p. 56.]

In Middle Cambrian time a group of trilobites lived in the Shan-tung sea that I have illustrated on plate 15 under the genera *Inouyia* and *Levisia*. Among the species described by von Toll from the limestone on the Lena river is one that appears to come within the genus *Levisia*. *Ptychoparia czekanowskii* von Toll [1899, plate 1, fig. 1] is exceedingly close to *Levisia agenor* (Walcott) [plate 14, fig. 19]; and *Ptychoparia meglitzkii* von Toll [1899, plate 1, fig. 2] has the broad, swollen anterior limb, broad free cheeks, and conical glabella of some of the *Inouyia* [plate 14, figs. 9, 12, 13, 15]. Von Toll describes three species of *Microdiscus* and *Agnostus schmidti* from the Lena limestone; also a species of *Hyolithes*, fragments of a trilobite doubtfully referred to *Olenellus*, and two brachiopods, *Kutorgina cingulata* Billings and *? Obolella* cf. *chromatica* Billings.

The general facies of this Lena limestone fauna led von Toll to place it in the Lower Cambrian, but in the absence of forms that are distinctly of Lower Cambrian age there remains a doubt. In any event the fauna is, with the exception of the two trilobites referred to *Ptychoparia* by von Toll, distinct from the fauna of the Shan-tung Province.

The two species of trilobites described by Schmidt from the banks of the Wilui [von Toll, 1899, p. 3] as *Anomocare pawlowskii* and *Liostracus ? maydeli*, are clearly Middle Cambrian forms and comparable with species that I have referred to the genus *Anomocarella* [plate 19] in respect to their large eyes and broad glabella, but not in their narrow frontal limb and rounded frontal rim. These trilobites indicate that in Middle Cambrian time there was no direct connection between the Shan-tung and Siberian provinces.

DESCRIPTION OF GENERA AND SPECIES.

FORAMINIFERA.

Genus GLOBIGERINA d'Orbigny.

Globigerina ? mantoensis Walcott.

Plate 1, Figure 1.

Globigerina ? mantoensis WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 10. (Described as below as a new species.)

A single specimen of what is probably a species of Foraminifera occurs in a compact, gray limestone. It is elongate-oval in shape, convex, and divided longitudinally by a narrow furrow into two lobes, which are marked by more or less irregularly arranged and not very deep depressions at right angles to the central furrow.

Formation and Locality.—Middle Cambrian: (C5) Lower limestone member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 39 (first list of fossils), and fig. 8*a* (bed 30), p. 29], 3.2 miles (5.1 km.), southwest of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Collected by Eliot Blackwelder.

PORIFERA.

Genus PROTOSPONGIA Salter.

Protospongia chloris Walcott.

Plate 1, Figures 2, 2*a*.

Protospongia chloris WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 10. (Described and discussed as a new species essentially as below.)

Of this species only the large primary spicules are known. The skeleton is not preserved. The siliceous spicules vary in size, but they all appear to be four-rayed. The rays are slender, extending out usually at right angles to each other from the center, but in some specimens one or more of the rays are occasionally diverted from the right angle; they slope slightly downward from the center to their extremities, which gives a low, pyramidal form to the spicule; there is no trace of a central, downward-pointing ray on the under side. Each ray has a rounded angle on its upper side; it is slightly angular at the sides and subangular on the lower side. In many examples the narrow rounded ridge of the upper side is exfoliated, leaving a V-shaped groove lengthwise of the ray; the grooves from the four rays unite at the center.

As a result of the exfoliation of the upper side of the ray there appear to be three forms of spicules: first, the complete spicule, as above described; second, a very slender spicule with the rays rounded on the upper side and angular on the lower side; and third, a spicule having a V-shaped groove on the upper side of the rays.

The spicules above described resemble in general form those of *Protospongia fenestrata* Salter [1864, p. 238, plate XIII, fig. 12]; they differ in the absence of the central ray and the exfoliation of the upper side of the ray. A similar spicule occurs in a hard shaly limestone about 200 feet (61 m.) above a white quartzitic sandstone in southern Manchuria.

Formation and Locality.—Middle Cambrian: (C1) Lower shale member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 40 (part of the third list of fossils), and fig. 10 (bed 4), p. 38], 2 miles (3.2 km.) south of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Collected by Eliot Blackwelder.

Also, Fu-chóu series (35q), about 200 feet (61 m.) above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general stratigraphic relations], and (35n), limestones near the base of the series just above the white quartzite [see idem]; collected in a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria, China.

Collected by J. P. Iddings and Li San.

Protospongia sp. undt.

Plate 1, Figure 4.

The species is represented by spicules the four branches of which are nearly on the same plane and meet in the center at right angles. The branches are round, very slender, 0.25 to 0.5 mm. in diameter, and scarcely increase in size from their base to the end, as now known.

Formation and Locality.—Middle Cambrian: (35n) Fu-chóu series; limestones near the base of the series just above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general section giving stratigraphic relations]; collected in a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria, China.

Collected by J. P. Iddings and Li San.

ANTHOZOA.

Genus COSCINOCYATHUS Bornemann.

Coscinocyathus BORNEMANN, 1884, Zeitschr. deutsch. geol. Gesellsch., vol. XXXVI, p. 704.

Coscinocyathus elvira Walcott.

Plate 1, Figures 3, 3*a*–*c*.

Coscinocyathus elvira WALCOTT, 1906, Proc. U. S. Nat. Mus., vol. XXX, p. 566. (Described and discussed as a new species, essentially as below.)

This species is represented by one small cup, a fragment of the interior wall of a larger cup, a thin section showing a portion of the wall, and a diagonally transverse section near the base of the cup. The cup has a height of 3 mm. and a diameter of 3 mm. at the aperture. The exterior surface appears smooth under a lens of moderate power, but with a strong lens it is found to be perforated by minute pores; the interior surface is marked by arching ridges, radiating from the base toward the outer edge, connected by transverse ridges, between which rounded pits occur. A diagonally transverse thin section shows the system of ridges described and the openings between them. The same section cuts across near the base of a cup. In this the calcite is so crystallized that no definite structure, with the exception of a few traces of septa extending from the inner wall to the outer wall, can be distinguished.

The specimen illustrating the interior wall, as shown by figure 3*a*, indicates a cup that expanded much more rapidly than the cup illustrated by figure 3. It may be that a second species is indicated by this, but with the material available for study it does not appear best to attempt to distinguish them by applying distinct names.

When the surface of the outer wall is slightly worn the radiating lines and transverse septa are very clearly shown.

The generic reference to *Coscinocyathus* is made on account of the presence of the regular cross-septa in addition to the radial septa, as defined by Dr. J. G. Bornemann [1884, p. 704]. None of the Siberian forms of the Archæocyathinæ described by Dr. Eduard von Toll [1899, pp. 38–53] appears to be closely related to this species.

The specific name is given in recognition of the work of Miss Elvira Wood in connection with the preliminary study of the Cambrian fauna of China.

Formation and Locality.—Middle Cambrian: (C75) Limestone near the base of the Ki-chóu formation [Willis and Blackwelder, 1907, p. 143], 4.5 miles (7.2 km.) south of Wu-t'ai-hién, Shan-si, China.

Collected by Eliot Blackwelder.

ANNELIDA.

Genus PLANOLITES Nicholson.

Planolites sp. undt.

Plate 1, Figure 5.

Casts of a small burrowing worm that penetrated in all directions the calcareous mud now forming thin layers of limestone. The specimen illustrated shows the casts of burrows on the line of the original surface of the mud. It suggests that a number of small worms had followed along the filled-in boring of a large worm.

Formation and Locality—Middle Cambrian: (36f) Fu-chóu series; about 1,000 feet (305 m.) above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general section giving stratigraphic relations]; collected in a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria, China.

Collected by J. P. Iddings and Li San.

BRACHIOPODA.

Genus MICROMITRA Meek.

For discussion of the genus *Micromitra* and its subgenera see Monogr. U. S. Geol. Survey, vol. LI, 1912, pp. 332–365.

Micromitra sculptilis (Meek).

Plate 1, Figures 6, 6*a*.

Iphidea (??) sculptilis MEEK, 1873, Sixth Ann. Rept. U. S. Geol. Survey Territories for 1872, p. 479. (Described and discussed as a new species, and the generic name *Micromitra* proposed in case the species should prove to belong to a new genus.)

Kutorgina minutissima HALL and WHITFIELD, 1877, U. S. Geol. Expl. 40th Parallel, vol. IV, pt. 2, pp. 207–208, plate I, figs. 11 and 12. (Described and discussed as a new species. The specimens represented by figs. 11 and 12 are redrawn by Walcott, 1912, plate III, figs. 5*b* and 5*c*.)

Kutorgina sculptilis (Meek), WALCOTT, 1884, Monogr. U. S. Geol. Survey, vol. VIII, p. 20, plate I, figs. 7, 7*a–b;* plate IX, fig. 7. (The specimens represented by figs. 7, 7*a–b*, plate I, and fig. 7, plate IX, are redrawn in this monograph, plate III, figs. 5, 5*b*, and 5*c*.)

Iphidea sculptilis Meek, SCHUCHERT, 1897, Bull. U. S. Geol. Survey No. 87, p. 235. (Merely goes back to original generic reference.)

Iphidea sculptilis Meek, WALCOTT, 1899, Monogr. U. S. Geol. Survey, vol. XXXII, pt. 2, pp. 447–448, plate LX, figs. 5, 5*a–c*. (Discussed. The specimen represented by figs. 5, 5*a–c* is redrawn by Walcott, 1912, plate III, fig. 5*a*.)

Iphidella sculptilis (Meek), WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXVIII, p. 308. (Merely changes generic reference.)

Micromitra sculptilis (Meek), WALCOTT, 1912, Monogr. U. S. Geol. Survey, vol. LI, pp. 341–342, plate III, figs. 5, 5*a–e*. (Describes, discusses, and illustrates species.)

A careful comparison of the type specimens of this species with the series of specimens from Manchuria shows them to be so similar in form and surface sculpture that I do not hesitate to identify the latter as *Micromitra sculptilis* (Meek). The species has a wide distribution in the Rocky Mountain Province of America, and it ranges from the Upper Cambrian down into the Middle Cambrian [Walcott, 1912*b*, pp. 341–342].

Formation and Locality.[1]—Middle Cambrian: (35n and 35r) Fu-chóu series; limestones near the base just above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general section giving stratigraphic relations]; collected in a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria, China.

Collected by J. P. Iddings and Li San.

PATERINA Beecher, Subgenus of MICROMITRA.

For discussion of the subgenus see Monogr. U. S. Geol. Survey, vol. LI, 1912, p. 343.

Micromitra (Paterina) labradorica orientalis (Walcott).

Plate 1, Figure 8.

Iphidella labradorica orientalis WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXVIII, pp. 305–306. (Characterized as below as a new variety.)

Micromitra (Paterina) labradorica orientalis (WALCOTT), 1912, Monogr. U. S. Geol. Survey, vol. LI, p. 348, plate II, fig. 11. (Copy of the preceding reference.)

Only one dorsal valve of this shell occurs in the collection. Its general form and surface characters are very much like those of *Micromitra (Paterina) labradorica swantonensis* (Walcott) [1912*b*, pp. 348–349, plate II, figs. 3, 3*a–f*]. The varietal name is given more on account of the fact that this shell occurs in China and the variety *swantonensis* on the eastern side of the North American continent than from any marked differences between the shells from the two localities. It may be that with a good series of shells from China differences would be found that are not to be determined with only the single shell for comparison.

Formation and Locality.—Middle Cambrian: (C5) Lower limestone member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 39 (first list of fossils), and fig. 8*a* (bed 30), p. 29], 3.2 miles (5.1 km.) southwest of Yen-chuang; and (C9), lower limestone member of the Kiu-lung group [idem (third list of fossils), and fig. 8*a* (bed 33), p. 29], 3 miles (4.8 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Micromitra (Paterina) lucina Walcott.

Plate 1, Figures 7, 7*a*.

Micromitra (Paterina) lucina WALCOTT, 1911, Smithsonian Misc. Coll., vol. 57, No. 4, pp. 73–74, plate 14, fig. 1. (Described and discussed as a new species, essentially as below.)

Ventral valve depressed subconical, with a minute beak curving over and concealing the pseudodeltidium. The cardinal slope is bent abruptly backward and downward so as to form a narrow false area on each side of a wide, open, triangular space. Dorsal valve transverse, gently convex, with the nearly straight posterior margin shorter than the greatest width of the valve; beak minute, marginal; false area unknown.

Surface marked by concentric, slightly irregular, rounded lines and ridges of growth that may or may not be grouped in bands of varying width. A dorsal valve shows a few fine, faint, radiating ridges.

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[1]Only the Chinese localities are here given; for the other occurrences of *M. sculptilis*, see Walcott, 1912*b*, pp. 341–342.

A ventral valve 3 mm. in width has a length of 2.75 mm. and a height of 1 mm. A dorsal valve with a width of 2.5 mm. has a length of 2 mm. and a height of 0.5 mm. at the beak.

In form the ventral valve of this species is not unlike that of *Micromitra sculptilis* (Meek) [p. 61], except that it is not so elevated and its surface is quite different. It is associated with *M. sculptilis* and the two varieties of *Micromitra* (*Iphidella*) *pannula, ophirensis* and *maladensis*.

Formation and Locality.—Middle Cambrian: Fu-chóu series: (35n and 35r) limestones and (36d) shales near the base, just above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general section giving stratigraphic relations]; collected in a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria, China.

Collected by J. P. Iddings and Li San.

IPHIDELLA Walcott, Subgenus of MICROMITRA.

For discussion of the subgenus see Monogr. U. S. Geol. Survey, vol. LI, 1912, p. 359.

Micromitra (Iphidella) pannula maladensis (Walcott).

Plate 1, Figures 9, 9*a*.

Iphidella pannula maladensis WALCOTT, 1905, Proc. U.S. Nat. Mus., vol. XXVIII, p. 306. (Description of variety.)

Micromitra (*Iphidella*) *pannula maladensis* (WALCOTT), 1912, Monogr. U.S. Geol. Survey, vol. LI, p. 364, plate IV, figs. 2, 2*a–g*. (Describes and illustrates the variety.)

This beautiful shell has been found in Newfoundland with the Atlantic Province Middle Cambrian fauna and in southern Idaho with the Rocky Mountain Province fauna [Walcott, 1912, p. 364, Monogr. LI]. It differs from the variety *ophirensis* of this species, with which it is associated (35n) in having a more network-like surface of sharp elevated ridges, and from *M.* (*I.*) *pannula* in having the surface network formed of sharper concentric ridges modified by fine, rounded, radiating ridges. These differences are shown by the illustrations on plate IV, Monogr. U. S. Geol. Survey, vol. LI.

Formation and Locality.—Middle Cambrian: (35n and 35r) Fu-chóu series; limestones near the base just above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general section giving stratigraphic relations]; collected in a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria, China.

Collected by J. P. Iddings and Li San.

Micromitra (Iphidella) pannula ophirensis (Walcott).

Plate 1, Figures 10, 10*a–b*.

Iphidella pannula ophirensis WALCOTT, 1905, Proc. U.S. Nat. Mus., vol. XXVIII, p. 306. (Characterized as a new variety.)

Micromitra (*Iphidella*) *pannula ophirensis* (WALCOTT), 1912, Monogr. U.S. Geol. Survey, vol. LI, p. 365, plate IV, figs. 4, 4*a–f*. (Describes and illustrates the variety.)

This variety of *Micromitra* (*Iphidella*) *pannula* is represented by several fine specimens occurring in a limestone similar in character to the limestone at Ophir City, Utah, containing the American specimens [Walcott, 1912*b*, p. 365]. In form and surface characters the shells from the two widely separated localities appear to be identical.

Formation and Locality.—Middle Cambrian: (35n) Fu-chóu series; limestones near the base, just above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general section giving stratigraphic relations]; collected in a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria, China.

Collected by J. P. Iddings and Li San.

Genus OBOLUS Eichwald.

For discussion of the genus *Obolus* see Monogr. U. S. Geol. Survey, vol. LI, 1912, pp. 370–380, text-figure 34, p. 374.

Obolus chinensis (Walcott).

Plate 1, Figures 11, 11*a–c*.

Obolus (*Lingulella*) *chinensis* WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXVIII, p. 328. (Species described and discussed as below.)

Obolus chinensis (WALCOTT), 1912, Monogr. U. S. Geol. Survey, vol. LI, p. 387, plate XXXIX, figs. 7, 7*a–b*. (A copy of the preceding reference.)

General form broadly subovate, with the ventral valve broadly subacuminate and the dorsal valve oval, with the postero-lateral slopes somewhat straightened. There is some variation in the proportions of width and length in different shells. Valves rather strongly convex for so thin a shell, in this respect resembling species of *Dicellomus*. Surface marked by fine, concentric striæ and lines of growth and very fine, undulating, concentric lines; this outer surface is usually a dull black and adheres to the matrix; when the outer layer is exfoliated the surface is shiny black and marked by numerous radiating striæ in addition to concentric striæ; the inner surface shows a few scattered punctæ in addition to radiating and concentric striæ outside the visceral area. The shell is of medium thickness and formed of a thin outer layer and several inner layers or lamellæ that are slightly oblique to the outer layer; the lamellæ are more numerous and more oblique to the outer layer over the anterior and antero-lateral portions of the shell. The ventral valves average 3 mm. in length, with width varying from 2 mm. to 2.5 mm.; the dorsal valve is slightly shorter than the ventral, when the two valves have the same width.

The interior of the ventral valve shows that the area is short and divided midway by a narrow pedicle furrow that merges into the visceral area, which extends forward about one-third the length of the valve; on each side of the anterior central portion of the visceral area there are two small trapezoidal areas within which the central scars and the middle and outside lateral muscle-scars were attached; the small transmedian and antero-lateral muscle-scars are situated close to the main vascular sinus opposite the anterior portion of the central visceral area. A partial cast of the interior of the dorsal valve shows a rather wide visceral area with the antero-lateral scars about the center of the valve and the central scars about one-fourth of the distance back from the center to the posterior margin. On the impressions left by the vascular system only the main vascular sinuses of the ventral valve have been seen; these are situated about midway between the central visceral area and the margins of the valve.

This species occurs abundantly in association with *Acrotreta shantungensis* [p. 76]. It is closely related in form to *Obolus prindlei* (Walcott) [1912, plate XXVII, figs. 3, 3*a–e*] of the upper *Olenellus* zone of eastern New York, and belongs with a group of small shells that have a wide vertical and geographical range, as is noted under the description of *O. prindlei*. With the data available for comparison it differs from *O. prindlei* in its shorter cardinal area and visceral area in the dorsal valve. From *Obolus damesi* [p. 65] it differs in being broader in proportion to its length.

This species is fairly common in southwestern Manchuria in the *Dorypyge richthofeni* zone in association with *Obolus damesi* Walcott. I find that the two species are very closely related and that when the valves of *O. damesi* are flattened and broadened by compression it is difficult to decide to which species they should be referred.

Formation and Locality.—Middle Cambrian: (C62) Earthy layer in the middle limestone of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 40 (last list of fossils), and fig. 10 (base of bed 7), p. 38], 2.5 miles (4 km.) south of Yen-chuang, on the north-northeast spur of Hu-lu-shan, Sin-t'ai district, Shan-tung, China.

Collected by Eliot Blackwelder.

Also (35n), Fu-chóu series: Limestones near the base of the series just above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general section giving stratigraphic relations]; collected in a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria, China.

Collected by J. P. Iddings and Li San.

Obolus damesi (Walcott).

Plate 2, Figures 1, 1*a–e*.

Obolus (*Lingulella*) *damesi* WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXVIII, p. 329. (Species described and discussed essentially as below.)

Lingulella damesi (WALCOTT), 1912, Monogr. U. S. Geol. Survey, vol. LI, p. 489, plate XXXIX, figs. 8, 8*a–c*. (A copy of the preceding reference. See footnote, p. 489.)

The general description of *Obolus chinensis* [p. 64] applies so closely to this species that it does not appear necessary to do more than call attention to the points in which they differ. From *O. chinensis* this species varies in having a more elongate, acuminate ventral valve and ovate dorsal valve; the valves are also less convex. The average size of the ventral valve is about 5 mm. in length by 3.5 mm. in width.

In Manchuria *O. damesi* occurs abundantly in the limestones and shales of the lower part of the *Dorypyge richthofeni* zone.

The species is named after Dr. Wilhelm Dames, who first described the Cambrian faunas of China.

Formation and Locality.—Middle Cambrian: (C10) Lower shale member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 40 (part of the third list of fossils), and fig. 8*a* (bed 35), p. 29], about 3 miles (4.8 km.) southwest of Yen-chuang; also (C7), lower limestone member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 39 (last list of fossils), and fig. 8*a* (bed 33), p. 29], 2.2 miles (3.5 km.) southwest of Yen-chuang; and (C64), upper limestone member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 42 (first list of fossils), and fig. 10 (bed 20), p. 38], 2.7 miles (4.3 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Collected by Eliot Blackwelder.

Also (35n, 35r, and 36e) Fu-chóu series: Limestones near the base of the series, just above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general section giving stratigraphic relations], collected in a low bluff on the shore of Tschang-hsing-tau island; and (35o and 36g) shales about 130 feet (40 m.) above the white quartzite [see idem], collected in drainage cuts a short distance back from the bluff (see 35n) forming the shore of Tschang-hsing-tau Island, also (36h) collected in a low bluff on the shore of Tschang-hsing-tau Island; and (36d) shales near the base of the series just above the white quartzite [see idem], collected in a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria, China.

Collected by J. P. Iddings and Li San.

Obolus matinalis (Hall)?[1]

Plate 2, Figures 2, 2*a*.

Lingulepis matinalis HALL, 1863, 16th Ann. Rept. N. Y. State Cab. Nat. Hist., p. 130, plate VI, figs, 12, 13. (Name proposed for the ovate form of shell associated with *Lingulepis pinnaformis*. which is illustrated by figs. 12 and 13.)

[1]The complete synonymy of this species will be found in vol. LI, Monographs U. S. Geol. Survey, 1912, pp. 400 and 402.

Obolus matinalis (Hall)? WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXVIII, p. 325. (Mentioned as below. Doubtfully identifies the species from China.)

Obolus matinalis (Hall)? WALCOTT, 1912, Monogr. U. S. Geol. Survey, vol. LI, p. 402, plate VIII, figs. 3 and 3*a*. (Copy of preceding reference.)

A form indistinguishable from this species occurs in a gray limestone of Upper Cambrian age. Only the general form of partly exfoliated shells is known.

Formation and Locality.—Middle Cambrian: (C54) Lower part of Ch'au-mi-tién limestone [Blackwelder, 1907*a*, p. 42 (part of last list of fossils)], near top of limestone knoll two-thirds of a mile (1.1 km.) west of Tsi-nan, Shan-tung, China.

Collected by Eliot Blackwelder.

Fragments of a similar shell were found in the (C67) stream gravels used in making the railroad grade west of the west city gate at Tsi-nan.

Collected by Eliot Blackwelder.

Obolus minimus Walcott.

Plate 2, Figures 3, 3*a*.

Obolus minimus WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXVIII, p. 325. (Described as below as a new species.)

Obolus minimus WALCOTT, 1912, Monogr. U. S. Geol. Survey, vol. LI, pp. 404–405, plate XI, figs. 8 and 8*a*. (Copy of the preceding reference.)

This is a small shell of the general form of *Obolus shansiensis* [p. 67]. The ventral valve is obtusely acuminate and the dorsal nearly circular; valves gently convex. Surface marked by rather strong, concentric lines of growth and numerous very fine, concentric striæ. The inner layers of shell are shiny black and ornamented with numerous fine, radiating striæ and concentric lines. Shell built up of several thin layers or lamellæ that form a shell which is thin over the umbonal region and gradually thickens toward the front and side margins, as the short oblique lamellæ become more numerous. The three specimens in the collection average 3 mm. in transverse diameter; the ventral is a little longer than the dorsal valve.

A partly exfoliated ventral valve shows a well-marked visceral area, extending forward about one-third of the length of the shell; also narrow main vascular sinuses starting near the apex and extending obliquely forward well into the valve, about midway between the median line of the valve and the lateral margins.

This neat little shell is distinguished by its nearly circular outline, low convexity, and small size.

Formation and Locality.—Middle Cambrian: (C1) Lower shale member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 40 (part of the third list of fossils), and fig. 10 (bed 4), p. 38], 2 miles (3.2 km.) south of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Collected by Eliot Blackwelder.

Obolus obscurus Walcott.

Plate 1, Figures 12, 12*a–d*.

Obolus obscurus WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXVIII, p. 326. (Described and discussed essentially as in the first two paragraphs below as a new species.)

Obolus obscurus WALCOTT, 1912, Monogr. U.S. Geol. Survey, vol. LI, pp. 406–407, plate XI, figs. 9, 9*a–d*. (Described and discussed essentially as below.)

This species is represented by one interior of a small dorsal valve which is very distinctive, the exterior of a crushed dorsal valve, and numerous fragments of the shell scattered through the hard, dark gray, shaly sandstone. The large dorsal valve has a length of 9 mm., width 7 mm. The shell is strong and marked on its

inner layers by radiating and concentric striæ; the outer surface has numerous fine, elevated, slightly irregular, concentric striæ that, with a strong lens, give it a roughened appearance.

An interior of a dorsal valve shows a well-developed area, the greater portion of which is taken by the broad pedicle groove; a deep umbonal cavity with a narrow median septum and obscure main vascular sinuses on the outer margins of the cavity. Outside the sinuses, on the postero-lateral slope, relatively large muscle-scars are indicated.

With the data available no satisfactory comparisons can be made with other species. *Obolus obscurus* is a large, strong shell of the general type of *Obolus rhea* Walcott [1912*b*, plate IX, figs. 1, 1*a–c*] of the Middle Cambrian of Wisconsin.

Since the publication of the original description of this species in 1905 better specimens referred to this species were received from the Middle Cambrian of Shan-si. These illustrate the form and convexity of the central valve, and show it to be similar to that of *Obolus chinensis* [p. 64]. The concentric ridges are more nearly perfect than those on the fragments associated with the type specimens from Shantung. The concentric striæ or ridges are elevated, rounded, with sharp depressions between them; the ridges are little more than elevated striæ at the aperture, becoming gradually coarser over the central and anterior portions of the valve, where there are from five to seven ridges in a distance of 1 mm.; toward the apex there are more than double the number in the same distance.

Obolus obscurus is a larger and more radiate shell than *O. chinensis*, and is also distinguished by the strong, concentrically striated surface, which resembles that of *Micromitra (Paterina) labradorica orientalis* [p. 62], from which it differs in the form of the shell. It differs from *O. (Acritis) antiquissimus* (Eichwald) [1843, plate 142; Walcott, 1912*b*, plate XIII, fig. 3, and plate XV, figs. 2, 2*a–d*] in having the concentric striæ or ridges more regular, and very rarely bifurcating. *Obolus (A. ?) rugatus* Walcott [idem, plate XIII, fig. 2] has much stronger concentric ridges. The surface of *O. nundina* Walcott [1905*a*, p. 326] is marked by irregularly spaced, rounded, concentric ridges, with rounded depressions between them instead of the V-shaped depressions and regularly spaced ridges of *O. obscurus*.

Formation and Locality.—Middle Cambrian: (C63) Sandy shale near the base of the Kiu-lung group [Blackwelder, 1907*a*, p. 37 (third paragraph), and fig. 8*a* (bed 32), p. 29], 3.5 miles (5.6 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung; also (C75) limestone near the base of the Ki-chóu formation [Willis and Blackwelder, 1907, p. 143], 4.5 miles (7.2 km.) south of Wu-t'ai-hién, Shan-si, China.

Collected by Eliot Blackwelder.

Obolus shansiensis Walcott.

Plate 2, Figures 4, 4*a–g*.

Obolus shensiensis WALCOTT, 1905, Proc. U.S. Nat. Mus., vol. XXVIII, p. 327. (Described and discussed essentially as below as a new species, the spelling "shensiensis" being an error, because the type specimens came from a locality in the Province Shan-si.)

Obolus shansiensis WALCOTT, 1912, Monogr. U. S. Geol. Survey, vol. LI, p. 415, plate XI, figs. 7, 7*a–c*. (A copy of the preceding reference.)

General form ovate, with the ventral valve broadly subacuminate and dorsal valve obtusely rounded. Valves moderately convex in the specimens embedded in a fine-grained, dark limestone. Surface marked by fine, sharp, concentric striæ and traces of irregular, obscurely defined, low, radiating ridges; the interior layers show fine, radiating striæ and concentric lines. The shell is strong and built up of numerous lamellæ oblique to the outer surface. The largest ventral valve has a length of 9 mm., width 7 mm. Nothing is known of the interior of the valves.

The form, surface markings, and shell structure are much like those of *Obolus matinalis* [p. 65] and *O. tetonensis* Walcott [1912*b*, plate IX, figs. 5, 5*a–d*]. In outline *O. shansiensis* is more elongate than *O. matinalis* and less so than *O. tetonensis*.

In Manchuria Prof. Joseph P. Iddings found this species to be abundant in the limestone and interbedded shale of the *Dorypyge richthofeni* zone.

Formation and Locality.—Upper Cambrian: (C37) Upper part of the Ki-chóu limestone (the fossils from this locality are not listed, but the presence of Cambrian strata at the locality is mentioned by Willis and Blackwelder [1907, p. 146]), in dense black limestone nodules in green-gray shales 10 feet (3 m.) below the base of the cliff limestone, 8 miles (12.8 km.) south of Ting-hiang-hién, Shan-si; and collected in (C32) Middle Cambrian; a fine-grained bluish-black limestone bowlder believed to have come from the lower part of the Ki-sin-ling limestone [Blackwelder, 1907*c*, p. 272], collected in river drift 1 mile (1.6 km.) south of Chön-p'ing-hién, on the Nan-kiang River, southern Shen-si, China.

A specimen which is closely related, if not identical with this species, has been found (C71) in massive cliff-making limestone in the central portion of the Ki-chóu formation [Willis and Blackwelder, 1907, pp. 139 and 145 (second list of fossils)], 4 miles (6.4 km.) southwest of Tung-yü, Shan-si, China.

Collected by Bailey Willis and Eliot Blackwelder.

Also (351), Middle Cambrian: Fu-chóu series; limestones near the base of the series just above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general section giving stratigraphic relations]; collected in a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria, China.

Collected by J. P. Iddings and Li San.

WESTONIA Walcott, subgenus of OBOLUS.

For discussion of the subgenus *Westonia* see Monogr. U.S. Geol. Survey, vol. LI, 1912, pp. 450–451.

Obolus (Westonia) blackwelderi Walcott.

Plate 2, Figures 5, 5*a–c*.

Obolus (*Westonia*) *blackwelderi* WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXVIII, p. 335. (Described and discussed as below.)

Obolus (*Westonia*) *blackwelderi* WALCOTT, 1912, Monogr. U.S. Geol. Survey, vol. LI, p. 453, plate XXXIX, figs. 10, 10*a–c*. (A copy of the preceding reference.)

General form elongate, with the width about one-half the length; front margin broadly rounded; sides slightly arched up to the lateral slopes, which are fairly straight in the ventral valve and curved toward the rounded posterior end of the dorsal valve; the beak of the ventral valve is pointed and marginal; the convexity of the valves is moderate, that of the dorsal apparently being the greater. Surface marked by concentric striæ and lines of growth which are crossed by irregular, fine, imbricating, more or less transverse lines; the transverse lines trend slightly backward toward the sides of the valves. A ventral valve 8 mm. in length has a width of 5 mm.

Nothing is known of the interior of the valves. When the shell is broken from the limestone, the outer surface usually adheres to the matrix. The best exteriors are those of shells on the surface of the layers. Of the known species of *Westonia*, *O.* (*W.*) *wimani* Walcott [1912*b*, plate XLVIII, figs. 5, 5*a–b*] and *O.* (*W.*) *balticus* Walcott [idem, plate XLVIII, figs. 7, 7*a–b*] are most nearly related to *O.* (*W.*) *blackwelderi*. The latter is a larger shell and also less narrow proportionally where the gently arching sides pass into the postero-lateral slopes.

Formation and Locality.—Middle Cambrian: Ch'ang-hia limestone (C1 and C2), lower shale member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 40 (part of the third list of fossils), and fig. 10 (beds 4 and 5), p. 38], 2 miles (3.2 km.) south of Yen-chuang, and (C6) thin, platy limestone in the upper shale member of the Kiu-lung group [idem, pp. 37 and 41 (second list of fossils), and fig. 10 (bed 12), p. 38], 2.5 miles (4 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Collected by Eliot Blackwelder.

Obolus (Westonia) sp. undt. Walcott.

Obolus (*Westonia*) sp. undt.*a* Walcott, 1912, Monogr. U. S. Geol. Survey, vol. li, p. 468. (Discussed.)

Fragments of shell marked with stronger transverse, irregular, sharp ridges occur a little higher in the Cambrian section of Shan-tung that clearly indicate a species of *Westonia* distinct from *Obolus* (*Westonia*) *blackwelderi* Walcott.

Formation and Locality.—Upper Cambrian: (C56) Lower part of Ch'au-mi-tién limestone, 25 feet (7.5 m.) below the top of Pagoda Hill [Blackwelder, 1907*a*, p. 42 (part of last list of fossils)], 1 mile (1.6 km.) west on Tsi-nan, Shan-tung, China.

Collected by Eliot Blackwelder.

Genus LINGULELLA Salter.

For discussion of this genus see Monogr. U. S. Geol. Survey, vol. li, 1912, pp. 468–474.

Lingulella manchuriensis Walcott.

Plate 3, Figures 1, 1*a–e*.

Lingulella manchuriensis Walcott, 1911, Smithsonian Misc. Coll., vol. 57, No. 4, p. 74, plate 14, figs. 2 and 2*a*. (Described and discussed as a new species essentially as below.)

This species and *Lingulella marcia* belong to a group of small, elongate, oval shells that are represented in the Rocky Mountain Province Cambrian fauna by *Lingulella manticula* (White) [Walcott, 1912*b*, plate xx, figs. 1, 1*a–c*], and the Atlantic Province fauna by *L. atava* (Matthew) [Walcott, 1912*b*, plate xxxv, figs. 5, 5*a–h*], *L. collicia* (Matthew) [Walcott, 1912*b*, plate xxxv, figs. 1, 1*a–e*], *L. ferruginea* Salter [Walcott, 1912*b*, plate xxix, figs. 1, 1*a–w*, 2, 2*a–f*, and plate xxxv, figs. 4, 4*a–b*], *L. nanno* (Walcott) [1912*b*, plate xxiv, figs. 1, 1*a–d*], and a number of similar forms illustrated on plates xxi and xxxv of Monograph li, U. S. Geological Survey. *L. manchuriensis* appears to be most nearly related to *L. similis* (Walcott) [1912*b*, plate xxi, figs. 2, 2*a–j*, 3, 3*a–d*]. It differs in the broader, more rounded posterior half of the ventral valve.

The average length of the ventral valve is 3 mm. among the large number of shells that occur in both limestone and shale.

Formation and Locality.—Middle Cambrian: (35p) Fu-chóu series; shales about 80 feet (24 m.) above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general section giving stratigraphic relations]; collected in a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria, China.

Collected by J. P. Iddings and Li San.

Lingulella marcia Walcott.

Plate 2, Figures 6, 6*a–f*.

Lingulella marcia Walcott, 1911, Smithsonian Misc. Coll., vol. 57, No. 4, pp. 74–75, plate 14, figs. 3 and 3*a*. (Described and discussed as a new species essentially as below.)

This species is one of the small forms allied to the group of similar shells mentioned under *L. manchuriensis*. It differs from the latter species in being

relatively broader in outline, with the sides of the valves less uniformly arched, and in having a more broadly rounded frontal margin.

Interiors of the ventral valve indicate that the area was relatively shorter than that of *L. similis* (Walcott) [1912*b*, plate XXI, figs. 2, 2*a–j*, 3, 3*a–d*]. Most of the shells in the limestone are less than 2 mm. in length; a few ventral valves in the shale are 3 to 5 mm. long.

Formation and Locality.—Middle Cambrian: (35q and 36h) Fu-chóu series; about 200 feet (61 m.) above the white quartzite; also in shales about 130 feet (40 m.) above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general section showing stratigraphic relations]; collected in a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria, China.

Collected by J. P. Iddings and Li San.

A form flattened in the shale of Locality 36f, which is much higher but in the same section as the locality represented by *L. marcia*, has the outline of the latter species and is tentatively referred to it. This gives an extended stratigraphic range for the species, but not so great as *L. similis* (Walcott) [1912*b*, pp. 532–534], which occurs in both the Middle and Upper Cambrian.

LINGULEPIS Hall, subgenus of LINGULELLA.

For discussion of subgenus *Lingulepis* see Monogr. U. S. Geol. Survey, vol. LI, 1912, pp. 544–545.

Lingulella (Lingulepis) eros (Walcott).

Plate 3, Figures 2, 2*a*.

Obolus (*Lingulepis*) *eros* WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXVIII, p. 333. (Described and discussed as below as a new species.)

Lingulella (*Lingulepis*) *eros* (WALCOTT), 1912, Monogr. U. S. Geol. Survey, vol. LI, p. 551, plate XXXIX, figs. 9 and 9*a*. (A copy of the preceding reference.)

Ventral valve elongate with rostral slopes gradually converging so as to form an acuminate beak. Surface marked by fine, concentric lines of growth and very fine, somewhat irregular, concentric striæ. Rather large, scattered punctæ occur on the interior surface.

This species is represented by fragments and two broken ventral valves; these indicate a length for the ventral valve of 7 to 10 mm.

It is allied to *Lingulepis acuminatus meeki* (Walcott)[1] of the Middle Cambrian fauna of the Teton Mountains of Wyoming.

Formation and Locality.—Middle Cambrian: (C7) Lower limestone member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 39 (last list of fossils), and fig. 8*a* (bed 33), p. 29], 2.2 miles (3.5 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Collected by Eliot Blackwelder.

Lingulella (Lingulepis?) sp. undt. (Walcott).

Obolus (*Lingulepis ?*) sp. undt. WALCOTT, 1906, Proc. U. S. Nat. Mus., vol. XXX, pp. 567–568. (Characterized as on page 71 as an independent species.)

Lingulella (*Lingulepis*) sp. undt. (WALCOTT), 1912, Monogr. U. S. Geol. Survey, vol. LI, p. 560, plate XXXIX, figs. 9 and 9*a*. (A copy of the preceding reference.)

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[1] *Lingulepis meeki* Walcott, 1897, Am. Jour. Sci., 4th ser., vol. III, p. 405.

This species is represented by a few fragments, one of which shows that the ventral valve is elongate and the apex acuminate. The shell was built up of several layers or lamellæ, as in characteristic forms of *Obolus* and its subgenera. The interior surface of some of the lamellæ is marked by fine radiating and concentric striæ; the outer surface, under a strong magnifier, shows fine, concentric, somewhat irregular striæ.

Formation and Locality.—Middle Cambrian: (C 72) Thin green-gray limestone interbedded with ocherous and green clay shales, overlying the massive oolite in the Ki-chóu formation [Willis and Blackwelder, 1907, pp. 139 and 145 (third list of fossils)], 4 miles (6.4 km.) east of Fang-lan-chön, Shan-si, China.

Collected by Eliot Blackwelder.

Genus DICELLOMUS Hall.

For discussion of genus see Monogr. U. S. Geol. Survey, vol. LI, 1912, pp. 571–572.

Dicellomus parvus Walcott.

Plate 3, Figures 3, 3*a–d.*

Dicellomus parvus WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXVIII, p. 315. (Described and discussed as a new species essentially as below.)

Dicellomus parvus WALCOTT, 1912, Monogr. U. S. Geol. Survey, vol. LI, pp. 574–575, plate LXXXIX, figs. 11, 11*a–d.* (An essential copy of the preceding reference.)

General form ovate, with the ventral valve subacuminate and dorsal valve broad oval to subcircular; valves moderately convex. Surface of outer shell dark and polished; it is marked, when not abraded, by fine, clearly defined, concentric striæ and occasional lines of growth. The largest ventral valve has a length of 2.5 mm., and a width of 2 mm. The shell is strong but not thick; shell substance apparently calcareo-corneous.

Ventral valve uniformly convex, except that the slopes toward the cardinal margins are more abrupt than elsewhere; apex appears to be marginal.

Dorsal valve somewhat less convex than the ventral; apex marginal. The interior of the valve shows well-defined, composite cardinal muscle-scars, a narrow median septum, and a faintly impressed main vascular sinus that curves outward and forward at about one-third the distance from the outer margin to the median septum; the central muscle-scars are small and situated back of the center of the valve on each side of a low median swelling on which the median septum occurs; the position of the antero-lateral muscle-scars is indicated at the end of the median septum a little in advance of the center of the valve.

This minute shell has the generic characters of *Dicellomus politus* (Hall) [Walcott, 1912*b*, pp. 575–578, plate LII], but it differs specifically in its minute size and the position of the muscle-scars in the dorsal valve.

Formation and Locality.—Middle Cambrian: (C 6) Thin, platy limestone in the upper shale member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 41 (second list of fossils), and fig. 10 (bed 12), p. 38], 2.5 miles (4 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Collected by Eliot Blackwelder.

Also from (C 32), a fine-grained, bluish-black limestone bowlder believed to have come from the lower part of the Ki-sin-ling limestone [Blackwelder, 1907*c*, p. 272], collected in river drift 1 mile (1.6 km.) south of Chön-p'ing-hién, on the Nan-kiang River, southern Shen-si, China.

Collected by Bailey Willis and Eliot Blackwelder.

Genus OBOLELLA Billings.

For discussion of genus see Monogr. U. S. Geol. Survey, vol. LI, 1912, pp. 586–588.

Obolella asiatica Walcott.

Plate 3, Figures 4, 4*a*.

Obolella asiatica WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXVIII, p. 297. (Described and discussed as below as a new species.)

Obolella asiatica WALCOTT, 1912, Monogr. U. S. Geol. Survey, vol. LI, pp. 588–589, plate LV, figs. 6, 6*a*. (A copy of the preceding reference.)

General form broad, oval, with the ventral valve showing a tendency to become bluntly acuminate. Valves gently convex. Surface of shell marked by concentric, raised lines of growth that form the front edge of narrow lamellæ of varying width; the raised lines are highest on their front side, which gives an imbricated appearance to the surface; fine, concentric striæ occur on the interspaces between the raised lines. Shell strong, calcareous.

The specimens occur in a compact, bluish-gray, oolitic limestone. None of them show the area or interior of the valves. The reference to *Obolella* is based on the general form and calcareous shell. The shells vary in size from 3 mm. to 5 mm.

Obolella asiatica may be compared with young shells of *O. crassa* (Hall) [*Orbicula? crassa* Hall, 1847, p. 290]. Its broadly elliptical form and slight convexity distinguish it from other species of the genus. It may be that if material is found showing the interior of the valves the generic reference will be changed, but with the data now available the reference is to *Obolella*.

The geological horizon is in some doubt, as the specimens were found in a block of river-drift limestone. The associated fragments of trilobites are too indefinite for determination. *Obolella* is a Lower Cambrian genus, as far as known, and other blocks of river limestone at the same locality contained fragments of *Olenellus*, so the reference of the species is made to the Lower Cambrian.

Since the publication of the above in 1905,[1] a specimen has been found in the collections from the upper portion of the Man-t'o shales that locates the species in a limestone somewhere from 90 to 180 feet (27.4 m. to 54.8 m.) below the Ch'ang-hia formation.

Formation and Locality.—Lower Cambrian: (C32′) A limestone bowlder collected in river drift 1 mile (1.6 km.) south of Chön-p'ing-hién, on the Nan-kiang River, southern Shen-si; also (C17), ferruginous limestone nodules in the brown sandy shales at the top of the Man-t'o shale [Blackwelder, 1907*a*, p. 27 (list of fossils at top of page), and fig. 6 (bed 15), p. 25], at Ch'ang-hia, Shan-tung, China.

Collected by Bailey Willis and Eliot Blackwelder.

Genus YORKIA Walcott.

Yorkia Walcott, 1897, Proc. U. S. Nat. Mus., vol. XIX, p. 714. (Described and discussed as a new genus.)

For discussion of the genus *Yorkia* see Monogr. U. S. Geol. Survey, vol. LI, 1912, p. 611.

Yorkia ? orientalis Walcott.

Plate 3, Figures 5, 5*a*.

Yorkia ? orientalis WALCOTT, 1906, Proc. U. S. Nat. Mus., vol. XXX, pp. 569–570. (Described and discussed as below as a new species.)

Yorkia ? orientalis WALCOTT, 1912, Monogr. U. S. Geol. Survey, vol. LI, p. 612, plate LXXXII, figs. 3, 3*a*. (A copy of the preceding reference.)

This species is represented by a single small ventral valve, which has the external characteristics of *Yorkia wanneri* [Walcott, 1897*b*, p. 715, plate LX, fig. 1], of the

[1] Proc. U. S. Nat. Mus., vol. XXVIII, 1905, p. 297.

Lower Cambrian. The outline of the valve is transversely and broadly oval in outline, exclusive of the apex rising above the posterior margin; the apex gives a subtriangular outline to the valve when looking down upon it; the apex is moderately elevated, and projects over the posterior margin; it is perforated by a rather large aperture just above a small false area.

The surface of the valve is marked by low, rather broad, concentric undulations, a few fine, concentric striæ, and a very finely reticulate ornamentation, formed by the crossing of oblique, elevated, curved lines, which form slightly elongate, diamond-shaped pits between them. Shell substance apparently calcareous. Width of ventral valve, 2.5 mm.; length, 2 mm. at aperture, 2.25 mm. at apex; elevation, 0.5 to 0.75 mm.

As far as may be determined by the exterior of the valve this species is properly referred to *Yorkia*. The generic reference, however, will remain in doubt until information is available as to the characters of the interior of the valve.

Formation and Locality.—Middle Cambrian: (C71) Massive cliff-making limestone in the central portion of the Ki-chóu formation [Willis and Blackwelder, 1907, pp. 139 and 145 (second list of fossils)], 4 miles (6.4 km.) southwest of Tung-yü, Shan-si, China.

Collected by Bailey Willis and Eliot Blackwelder.

Genus ACROTHELE Linnarsson.

For description and discussion of genus see Monogr. U. S. Geol. Survey, vol. LI, 1912, pp. 630–634.

Acrothele matthewi eryx Walcott.

Plate 3, Figures 6, 6*a–h*.

Acrothele matthewi eryx WALCOTT, 1905, Proc. U.S. Nat. Mus., vol. XXIX, p. 11. (Original description of variety.)

Acrothele matthewi eryx WALCOTT, 1912, Monogr. U. S. Geol. Survey, vol. LI, p. 649, plate LXI, fig. 2. (Description and illustration of variety.)

The first identification of this species in China [Walcott, 1905*b*, p. 11] was based on a single ventral valve 6 mm. in diameter. In the J. P. Iddings collection from southern Manchuria there is a fine series of specimens showing many characters of both the ventral and dorsal valves. These, when compared with *Acrothele matthewi* (Hartt) [Walcott, 1912*b*, pp. 647–649, plate LXI, figs. 1, 1*a–g*], indicate only a varietal difference between the widely separated forms. In fact, if the Asiatic and American specimens were all from the same locality and layer of rock, it is doubtful if I would separate one from the other even as a variety. The illustrations of the American shells [Walcott, 1912*b*, plate LXI, figs. 1, 1*a–i*] and the Asiatic shells [plate 3 of this paper] afford the student the means of comparison of specimens from the two continents.

The shell is built up of several layers of lamellæ that are smooth and shiny on the interior, except where slightly roughened by slight vascular markings and obscure radiating striæ. The outer surface is dull and marked by concentric striæ and lines of growth, and numerous fine, irregular, often anastomosing, elevated lines that give the surface a rough appearance.

Most of the valves are slightly broader than long. The largest ventral valve in a limestone matrix has a length of 7.5 mm.; width, 8.5 mm.; and the apex is 1.5 mm. in advance of the posterior margin; a large dorsal valve has a length of 11 mm.; width, 12.5 mm.

Formation and Locality.—Middle Cambrian: (C4) Limestone nodules at the base of the lower shale member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 40 (second list of fossils), and fig. 10 (bed 4), p. 38], 3 miles (4.8 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Collected by Eliot Blackwelder.

Also at the following localities: (35n and 35r) Fu-chóu series; limestones, and (36e) shales interbedded with limestones, near the base of the series just above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general section giving stratigraphic relations]; collected in a low bluff on the shore of Tschang-hsing-tau Island; and (35o and 36g) shales, about 130 feet (40 m.) above the white quartzite [see Blackwelder, idem], collected in drainage cuts a short distance back from the bluff [see 35n] forming the shore of Tschang-hsing-tau Island; all east of Niang-niang-kung, Liau-tung, Manchuria, China.

Collected by J. P. Iddings and Li San.

Acrothele ? minuta Walcott.

Plate 3, Figure 7.

Acrothele ? minuta WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXVIII, p. 303. (Described as below as a new species.)

Acrothele ? minuta WALCOTT, 1912, Monogr. U. S. Geol. Survey, vol. LI, p. 650, plate LXIII, fig. 3. (A copy of the preceding reference.)

Shell minute, 1.5 mm. in diameter, subcircular in outline, gently convex, with a slight median depression from the umbo to the anterior margin; back of the umbo there is a sharp median depression between minute ridges, on each of which there are two points of nipples. Surface marked by fine, concentric striæ. Substance of shell apparently phosphatic.

This interesting little species is represented by a single specimen. The generic reference is somewhat doubtful.

Formation and Locality.—Middle Cambrian: (C6) Thin, platy limestone in the upper shale member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 41 (second list of fossils), and fig. 10 (bed 12), p. 38], 2.5 miles (4 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Collected by Eliot Blackwelder.

Acrothele rara Walcott.

Plate 3, Figures 8, 8*a*.

Acrothele rarus WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXVIII, p. 303. (Described and discussed as below as a new species.)

Acrothele rara WALCOTT, 1912, Monogr. U. S. Geol. Survey, vol. LI, pp. 656–656, plate LXIII, figs. 4 and 4*a*. (A copy of the preceding reference.)

Of this shell only the interiors of the valves are known. Shells of average size are about 3.5 mm. in diameter. The outline of the valve is subcircular, the transverse diameter being slightly more than the length of the valve; the interior of the ventral valve shows that the valve was moderately convex, with a perforated apex about 0.5 mm. from the posterior margin; a short, broad median ridge extends for a short distance in front of the foraminal opening and short, narrow ridges extend obliquely forward from each side of the opening; what may be the lateral muscle-scars occur close to the postero-lateral margins. In the dorsal valve a strong median ridge extends from the posterior margin to the center of the valve; this ridge is angular at the summit and broadest toward its anterior end; a vascular sinus starts on each side of the base of the median ridge and extends obliquely forward.

The dark interior surface of the valves is marked by concentric lines that give a somewhat laminated appearance to the surface. From the manner in which the shell adheres to the limestone matrix it is probable that its outer surface is roughened by raised lines, somewhat as on *Acrothele subsidua* (White) Walcott [1912*b*, plate LX, figs. 1, 1*a*–*o*].

The data for comparison of this species with described species from America and Europe are too limited to be of value. A comparison with *Acrothele* (*Redlichella*) *granulata* (Redlich)[1] Walcott [1912*b*, p. 633, plate LVI, figs. 2, 2*a*–*n*], of the Salt Range, India, shows a strong similarity in the interiors of the dorsal valves; but I do not think it is probable that the two forms are specifically identical, as the interiors of the valves of several species of *Acrothele* appear very much alike.

Formation and Locality.—Middle Cambrian: (C57) In limestone nodules in the lower shale member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 40 (first list of fossils)], 3 miles (4.8 km.) south of Kao-kia-p'u, and 4 miles (6.4 km.) north of Sin-t'ai-hién, Sin-t'ai district, Shan-tung, China.

Genus ACROTRETA Kutorga.

For description and discussion of the genus *Acrotreta* see Monogr. U. S. Geol. Survey, vol. LI, 1912, pp. 671–674.

Acrotreta lisani Walcott.

Plate 3, Figures 9, 9*a*–*c*.

Acrotreta liani WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXVIII, p. 300. (Described and discussed as below as a new species. Li San's name was at that time believed to be correctly written as Lian, hence the form of the specific name.)

Acrotreta lisani WALCOTT, 1912, Monogr. U. S. Geol. Survey, vol. LI, pp. 692–693, plate LXVIII, figs. 3, 3*a*–*c*. (A copy of the preceding reference.)

Shell small, about 1.5 mm. in diameter; outline of aperture subcircular, the posterior side being slightly transverse. Ventral valve conical, with the apex a little in advance of the posterior margin; false area indefinite, except for a rather strong, flat furrow that extends from the apex to the margin; the elevation of the valve is about two-thirds of the diameter at its aperture. Dorsal valve slightly convex, apex marginal. Surface of shell marked by fine, concentric striæ and lines of growth that on the dorsal valve tend to form low ridges toward the outer margins.

This species is the representative of the American *Acrotreta idahoensis sulcata* Walcott [1912*b*, p. 690, plate LXV, fig. 5]. It has the same type of false area, and the ventral valve is of average height. The specific name is given in recognition of Li San, Mr. Willis's faithful Chinese interpreter.

Formation and Locality.—Middle Cambrian: (C22) Ch'ang-hia limestone in upper oolitic portion [Blackwelder, 1907*a*, pp. 22 and 33 (part of last list of fossils)], at Ch'ang-hia, Shan-tung, China.

Collected by Eliot Blackwelder.

Acrotreta pacifica Walcott.

Plate 4, Figures 1, 1*a*–*f*.

Acrotreta pacifica WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXVIII, p. 301. (Described as below as a new species.)

Acrotreta pacifica WALCOTT, 1912, Monogr. U. S. Geol. Survey, vol. LI, p. 699, plate LXIX, figs. 6, 6*a*–*e*. (A copy of the preceding reference.)

Ventral valve a high cone, with the apex a little in advance of the posterior margin; base circular, with the exception of a slight flattening on the posterior side; apex acute and pointing upward; false area only a slight flattening of the shell from the apex to the margin. The largest ventral valve has a diameter and height of about 1.5 mm. Surface marked by fine, concentric striæ that continue without noticeable deflection across the false area.

[1] *Mobergia granulata* Redlich, 1901, Mem. Geol. Surv. India, n. ser., vol. I, p. 5, plate I, figs. 11–18.

Two specimens of the ventral valve of this species are figured. One of these has a slightly transverse, broadly oval base, and a more definite false area. The species is closely related to *Acrotreta idahoensis alta* Walcott [1912*b*, p. 689, plate LXV, figs. 4, 4*a*–*b*], except that the ventral valve is not quite so elevated.

Acrotreta pacifica occurs in large numbers in a hard shale and shaly limestone in southwestern Manchuria. It is associated with *Dorypyge richthofeni* both in Shantung and Manchuria.

Formation and Locality.—Middle Cambrian: (C 1 and C 2) Lower shale member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 40 (part of the third list of fossils), and fig. 10 (beds 4 and 5), p. 38], 2 miles (3.2 km.) south of Yen-chuang; also (C4), limestone nodules at the base of the lower shale member of the Kiu-lung group [idem (second list of fossils), and fig. 10 (bed 4), p. 38], 3 miles (4.8 km.) southwest of Yen-chuang, and (C5) lower limestone member of the Kiu-lung group, idem, pp. 37 and 39 (first list of fossils), and fig. 8*a* (bed 30), p. 29], 3.2 miles (5.1 km.) southwest of Yen-chuang, and (C12) gray limestone near the top of the middle limestone member of the Kiu-lung group [idem, pp. 37 and 41 (part of the first list), and fig. 10 (bed 7), p. 38], 3.25 miles (5.2 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Collected by Eliot Blackwelder and Li San.

Also (35p), Fu-chóu series; shales about 80 feet (24 m.) above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general section giving stratigraphic relations]; collected in a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria, China.

Collected by J. P. Iddings and Li San.

A single dorsal valve similar in outline to those of this species as found in Manchuria (35p) occurs in the Ch'ang-hia formation, Locality C24. It may be compared but not identified with *A. pacifica*, as the dorsal valves of many of the species of *Acrotreta* are very much alike.

This dorsal valve is from Locality C24, Middle Cambrian, near the top of the black oolite group in the uppermost layers of the Ch'ang-hia formation [Blackwelder, 1907*a*, p. 33, part of last list of fossils], 2 miles (3.2 km.) east of Ch'ang-hia, Shan-tung, China.

Collected by Eliot Blackwelder.

Acrotreta shangtungensis Walcott.

Plate 4, Figures 2, 2*a*–*e*.

Acrotreta shantungensis WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXVIII, pp. 301–302. (Described and discussed as below as a new species.)

Acrotreta shantungensis WALCOTT, 1912, Monogr. U. S. Geol. Survey, vol. LI, pp. 710–711, plate LXIX, figs. 5, 5*a*–*e*. (A copy of the preceding reference.)

Shell small. Ventral valve a low cone with the apex a little forward of the posterior margin, which is slightly flattened; apex minute, directed backward and projecting slightly over the faintly defined false area. The cast of the interior shows that the apical callosity was rather large and the main vascular sinuses were well defined on each side of it; the cardinal scars are small and not prominent.

Dorsal valve slightly convex; apex marginal; surface marked by a rather broad, shallow median depression that begins on the umbo and gradually widens toward the front margin. The interior of the dorsal valve has a strong median ridge extending from the posterior margin two-thirds the distance toward the front; a small, elevated cardinal scar occurs on each side of the median ridge a little in advance of the pos-

terior margin; main vascular sinuses rather strong; they start beneath the apex and extend forward a short distance from the outer lateral margin of the shell. Surface marked by fine, concentric striæ and lines of growth.

This shell in size and general form is closely related to *Acrotreta microscopica* (Shumard) [Walcott, 1912*b*, plate LXVII, figs. 1, 1*a–h*, 1*o*, 2, 2*a–d*] of the Middle Cambrian fauna of the United States. It occurs abundantly in a chocolate-colored limestone associated with *Obolus chinensis* [p. 64].

Formation and Locality.—Middle Cambrian: (C62) Earthy layer in the middle limestone of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 40 (last list of fossils), and fig. 10 (base of bed 7), p. 38], 2.5 miles (4 km.) south of Yen-chuang, on the north-northeast spur of Hu-lu-shan, Sin-t'ai district, Shan-tung, and (C37) Upper Cambrian, upper part of the Ki-chóu limestone (the fossils from this locality are not listed, but the presence of Cambrian strata at the locality is mentioned by Willis and Blackwelder [1907, p. 146]), in dense black limestone nodules in green-gray shales 10 feet (3 m.) below the base of the cliff limestone, 8 miles (12.8 km.) south of Ting-hiang-hién, Shan-si, China; also (C71), Middle Cambrian, massive cliff-making limestone in the central portion of the Ki-chóu formation [Willis and Blackwelder, 1907, pp. 139 and 145 (second list of fossils)], 4 miles (6.4 km.) southwest of Tung-yü, Shan-si, and (C32) a fine-grained bluish-black limestone bowlder believed to have come from the lower part of the Ki-sin-ling limestone [Blackwelder, 1907*c*, p. 272], collected in river drift 1 mile (1.6 km.) south of Chön-p'ing-hién, on the Nan-kiang River, southern Shen-si, China.

This species is somewhat doubtfully identified from the Middle Cambrian of Locality C1, lower shale member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 40 (part of the third list of fossils), and fig. 10 (bed 4), p. 38], 2 miles (3.2 km.) south of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Collected by Bailey Willis and Eliot Blackwelder.

In Manchuria Prof. J. P. Iddings found this species in great abundance both in limestones and shales of the *Dorypyge richthofeni* zone in association with *Obolus chinensis* at the following localities.

Formation and Locality.—Middle Cambrian: (35n and 35r) Fu-chóu series; limestones near the base of the series just above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general section giving stratigraphic relations], collected in a low bluff on the shore of Tschang-hsing-tau Island, and (35o and 36g) shales about 130 feet (40 m.) above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general section giving stratigraphic relations], collected in drainage cuts a short distance back from the bluff [see 35n] forming the shore of Tschang-hsing-tau Island, and (36h) shales about 130 feet (40 m.) above the white quartzite [idem, 1907*b*, p. 92], collected in a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria, China.

Collected by J. P. Iddings and Li San.

Acrotretra venia Walcott.

Plate 3, Figures 10, 10*a–b*.

Acrotreta venia WALCOTT, 1911, Smithsonian Misc. Coll., vol. 57, No. 4, p. 75, plate 14, figs. 4 and 4*a*. (Described and discussed as a new species essentially as below.)

Acrotreta venia is closely related to *A. shantungensis* Walcott [p. 76]. It differs in having a slightly less elevated ventral valve and a broader and more distinct flattening of the posterior side and margin. The faintly defined false area and apex of the valve curve slightly over the posterior margin. The dorsal valve does not show the median depression of the dorsal valve of *A. shantungensis*. Of the Amer-

ican Pacific Province species of *Acrotreta* it most nearly approaches *A. idahoensis* Walcott [1912*b*, plate LXV, figs. 1, 1*a–i;* plate LXVIII, figs. 2, 2*a–g*] in the external form of the valves. The vascular markings on the interior of the dorsal valve differ in detail, as may be seen by comparing them.

Formation and Locality.—Middle Cambrian: (35q) Fu-chóu series; about 200 feet (61 m.) above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general stratigraphic relations], collected in a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria, China.

Collected by J. P. Iddings and Li San.

Acrotreta sp. undt.

In the Upper Cambrian limestone a single dorsal valve has been found at each of two localities (C56 and C68) that resembles the dorsal valve of *A. pacifica*, [p. 75] but in the absence of ventral valves I shall not attempt to identify them with any described species from the Middle Cambrian, or describe as new species.

Formation and Locality.—Middle Cambrian: (C56) Lower part of Ch'au-mi-tién limestone, 25 feet below the top of Pagoda Hill [Blackwelder, 1907*a*, p. 42 (part of last list of fossils)], 1 mile (1.6 km.) west of Tsi-nan, Shan-tung, and (C68) upper part of the Ch'au-mi-tién limestone [idem, p. 36 (part of third list of fossils)], on crest of ridge east of Ch'au-mi-tién, 200 yards (183 m.) north of the wayside shrine, Ch'ang-hia district, Shan-tung, China.

Collected by Eliot Blackwelder and Li San.

Genus DISCINOPSIS Matthew.

Discinopsis (Matthew MS.) HALL and CLARKE, 1892, 11th Ann. Rept. State Geologist New York for 1891, pp. 250–251. (Described.)

Discinopsis Matthew, HALL and CLARKE, 1892, 45th Ann. Rept. New York State Museum for 1891, pp. 566–567. (Copy of preceding reference.)

Discinopsis Matthew, HALL and CLARKE, 1892, Nat. Hist. New York, Paleontology, vol. VIII, pt. 1, pp. 105–106. (Described and discussed as a new genus.)

Discinopsis Matthew, WALCOTT, 1908, Smithsonian Misc. Coll., vol. LIII, No. 4, plate XI, and pp. 142 and 146. (Classification of genus.)

Discinopsis Matthew, WALCOTT, 1912, Monogr. U. S. Geol. Survey, vol. LI, p. 720. (The original description of *Acrotreta ? gulielmi* is copied and the genus is discussed under *Discinopsis gulielmi*, pp. 720–721).

Discinopsis gulielmi (Matthew).

The original diagnosis of the genus by Matthew was combined with that of the type species, *Acrotreta ? gulielmi*, as follows:

"Shell subcircular in outline. Surface depressed-conical, apices eccentric, not marginal. Pedicle valve with the apex truncated by a circular foraminal aperture (?). The interior of this valve is characterized by a pair of deep, diverging furrows, passing forward from the beak or internal foraminal opening, in broad curves which converge toward the anterior margin but without meeting. These furrows enclose a thickened and somewhat elevated central area, which in the subumbonal region is apparently free, projecting for a short distance, like a narrow, triangular shelf, beneath which the foramen probably opened. The interior opening of the foramen is, however, not apparent on any of the specimens examined, for, as usually preserved, the matrix has adhered to this subapical cavity, and in a single example only is the shelf-like character of the median area distinctly demonstrated. A faint longitudinal ridge passes from the apex of the shelf to the anterior margin, but no other markings are discernible on the interior except faint radiating or slightly undulating, probably vascular lines.

"The interior of the brachial valve, as far as known, shows no other characters than the radiating lines, which appear to belong to the ornamentation of the outer surface.

"Shell substance tenuous, apparently corneous. External surface covered with more or less prominent, sometimes lamellose concentric growth lines, crossed by fine, gently curved, radiating striæ which are usually more prominent when the concentric lines are exfoliated."

Discinopsis sulcatus (Walcott).

Plate 4, Figure 3.

Craniella ?? sp. WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, pp. 4 and 6. (Listed.)

Discinopsis sulcatus (WALCOTT), 1906, idem, vol. XXX, pp. 568–569. (Described and discussed as below as a new species.)

Discinopsis ? sulcatus (WALCOTT), 1912, Monogr. U. S. Geol. Survey, vol. LI, p. 721, plate LXXXII, fig. 6. (Copy of the preceding reference.)

This species is based upon the cast of the interior of a small ventral valve, that in its interior markings closely approaches the interior of the ventral valve of *Discinopsis gulielmi* (Matthew) [Walcott, 1912*b*, plate LXXXII, figs. 5, 5*a–c*].

The interior cast shows that the ventral valve was subcircular in outline, moderately convex, and with the apex probably perforated by a small, circular foraminal aperture. In front of the cast of the base of the foraminal aperture there is a broad depression that extends to the front margin; on each side of the central depression an elongate, slightly depressed area extends forward and outward from near the base of the cast of the foraminal aperture, along the ridge on each side of the median depression; back of the base of the foraminal aperture there is a narrow, short, arched furrow that indicates the presence of a corresponding ridge on the interior of the shell. No other markings are shown on the cast, except the faint outline of what may have been the visceral area, on the median line in front of the base of the foraminal aperture and between the broad vascular sinuses.

This species is referred to the genus *Discinopsis* as the result of comparison with specimens of the interior of a ventral valve of *D. gulielmi*. One interior of the latter species has scars much like those shown in *D. sulcatus*, figure 7.

Formation and Locality.—Upper Cambrian: (C56) Lower part of Ch'au-mi-tién limestone, 25 feet (7.5 m.) below the top of Pagoda Hill [Blackwelder, 1907*a*, p. 42 (part of last list of fossils)], 1 mile (1.6 km.) west of Tsi-nan, Shan-tung, China.

Collected by Eliot Blackwelder.

Genus BILLINGSELLA Hall and Clarke.

For discussion of the genus *Billingsella* see Monogr. U. S. Geol. Survey, vol. LI, 1912, pp. 749–750.

Billingsella pumpellyi Walcott.

Plate 4, Figures 4, 4*a–c*.

Billingsella pumpellyi WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXVIII, p. 242. (Described and discussed as below as a new species.)

Billingsella pumpellyi WALCOTT, 1912, Monogr. U. S. Geol. Survey, vol. LI, pp. 760–761, plate XCVII, figs. 8, 8*a–c*. (Copy of the preceding reference.)

General outline subsemicircular, greatest width at the hinge-line, or a little in advance of it; considerable variation exists in the relative proportions of length and width; a ventral valve 8 mm. long has a width of 9 mm.; the dorsal valve is more transverse, length 5.5 mm., width 8 mm. The ventral valve is strongly convex,

with the umbo arching over to the apex, which is a little above the plane of the margins of the valve; a very slight median fold occurs near the front margin; dorsal valve slightly convex and with a shallow median sinus.

The surface is marked by low, sharp ribs with wide interspaces, on which fine radiating striæ occur. Concentric lines and striæ of growth cross the radiating striæ and ribs.

The characters of the cardinal areas of the valves are almost unknown; that of the ventral valve appears to have been of moderate height and inclined but a little from the plane of the valve; one interior of the dorsal valve shows a low cardinal process. The cast of the interior of the ventral valve shows the presence of a tripartite, elevated umbonal space into which the strong main vascular sinuses extend, as in *Billingsella coloradoensis* (Shumard) [Walcott, 1912*b*, plate LXXXV, figs. 1, 1*a–z*]; the sinuses extend forward nearly to the front margin of the valve. On the interior of the dorsal valve only the presence of a strong median ridge is known.

This species is one of the costate forms of the type of *B. coloradoensis* (Shumard) and *B. romingeri* (Barrande) [Walcott, 1912*b*, plate XC, figs. 2, 2*a–n*]. It differs from them in surface characters. It may be considered the trans-Pacific representative of *B. coloradoensis*.

The specific name is given in recognition of the work of Raphael Pumpelly upon the geology of China.

Formation and Locality.—Upper Cambrian: (C61) A dense black limestone in the uppermost limestone member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 41 (third list of fossils), and fig. 10 (bed 13), p. 38], 3 miles (4.8 km.) southwest of Yen-chuang, Shan-tung; also (C36) upper part of the Ch'au-mi-tién limestone [idem, p. 36 (part of third list of fossils), and fig. 9 (bed 2), p. 35], at Ch'au-mi-tién, Ch'ang-hia district, Shan-tung, China.

This species is somewhat doubtfully identified from Lower Cambrian, (C20) central part of the Man-to shale formation [Blackwelder, 1907*a*, p. 26 (last list of fossils), and fig. 6 (bed 14), p. 25], on the west side of an isolated butte 1 mile (1.6 km.) south of Ch'ang-hia, Shan-tung, China.

The first collected by Li San; the second and third by Eliot Blackwelder.

Billingsella richthofeni Walcott.

Plate 4, Figure 5.

Billingsella richthofeni WALCOTT, 1905, Proc. U.S.Nat. Mus., vol. XXVIII, p. 242. (Characterized and discussed as below as a new species.)

Billingsella richthofeni WALCOTT, 1912, Monogr. U.S. Geol. Survey, vol. LI, pp. 761–762, plate LXXXIX, fig. 1. (Copy of the preceding reference.)

This species is represented by two specimens of the exterior of the ventral valve. They vary from 4 to 5 mm. in length and width, the length and width being about the same. The outer surface is marked by fine, obscure, radiating ribs and very fine, concentric striæ. The general form is much like that of the ventral valve of *Billingsella pumpellyi* [p. 79]. It differs from the latter in having a shorter hinge-line in proportion to the width, in the stronger and more nearly uniform convexity of the surface, and the more elevated apex.

The species is named after Dr. Ferdinand von Richthofen.

Formation and Locality.—Lower Cambrian: (C3) Lower part of the Man-t'o shale formation [Blackwelder, 1907*a*, p. 28 (list of fossils at bottom of page), and fig. 8*a* (bed 20), p. 28], on the southeast slope of Hu-lu-shan, 2.5 miles (4 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung, China.

A single specimen of a fragmentary ventral valve of a species of *Billingsella* that may belong to this species occurs in the central part of the Man-t'o shale. It was found (C20) [Blackwelder, 1907*a*, p. 26 (last list of fossils), and fig. 6 (bed 14), p. 25] on the west side of an isolated butte 1 mile (1.6 km.) south of Ch'ang-hia, Shan-tung, China.

Collected by Eliot Blackwelder.

Genus EOORTHIS Walcott.

For discussion of the genus *Eoorthis* see Monogr. U. S. Geol. Survey, vol. LI, 1912, p. 772.

Eoorthis agreste (Walcott).

Plate 4, Figures 6, 6*a*.

Orthis (*Plectorthis*) *agreste* WALCOTT, 1906, Proc. U. S. Nat. Mus., vol. XXX, p. 570. (Described as below as a new species.)

Eoorthis agreste (WALCOTT), 1912, Monogr. U. S. Geol. Survey, vol. LI, pp. 773–774, plate LXXXIX, figs. 6, 6*a*. (Copy of the preceding reference.)

Shell transverse, subsemicircular; a ventral valve 9 mm. in length has a width of 12 mm. and a hinge-line 10.5 mm. in length; ventral valve moderately and regularly convex, with the apex curved down to an area that is slightly inclined backward from the hinge-line; the details of the cardinal area are unknown.

Surface marked by rounded, radiating ribs and interspaces, six ribs in a space of 3 mm. near the front margin; a few of the ribs bifurcate, but most of them extend from the umbo to the front margin; the ribs are crossed by fine, concentric striæ and strong lines of growth.

This shell is characterized by its regular convexity and the uniformity of the rounded, radiating ribs.

Formation and Locality.—Middle Cambrian: (C28) Thin-bedded oolitic limestone at the base of the Ch'ang-hia limestone [Blackwelder, 1907*a*, p. 32 (first list of fossils), and fig. 6 (bed 20), p. 25], just above the shales in the face of the cliff 1 mile (1.6 km.) east-southeast of Ch'ang-hia, Shan-tung, China.

Eoorthis doris (Walcott).

Plate 4, Figures 7, 7*a*.

Orthis (*Plectorthis*) *doris* WALCOTT, 1905, Proc. U.S. Nat. Mus., vol. XXVIII, pp. 262–263. (Described and discussed as below as a new species.)

Eoorthis doris (WALCOTT), 1912, Monogr. U. S. Geol. Survey, vol. LI, p. 779, plate XCVII, figs. 13, 13*a*. (Copy of the preceding reference.)

Of this species a ventral and a dorsal valve occur in the collection. The general form is rounded subquadrangular. The ventral valve is strongly convex, with the greatest height at the umbo, from which the beak arches over a high, backward inclining area. The dorsal valve is much like the ventral in form, except that it is less convex and less elevated at the area. Surface of both valves with numerous radiating ribs that have an angular summit and an angular depression between them; the ribs increase in number toward the front by interpolation. The ventral valve has a length of 7 mm.; width, 8 mm. The dorsal valve is a little shorter than the ventral.

This shell is not unlike *Eoorthis indianola* (Walcott) [1912*b*, plate XCIV, figs. 1*t*, 2, 2*a*–*h*] in form and surface characters. It differs in being more convex and in the absence of a sinus or median fold on either valve.

Formation and Locality.—Upper Cambrian: (C64) Upper limestone member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 42 (first list of fossils), and fig. 10 (bed 20), p. 38], 2.7 miles (4.3 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Collected by Eliot Blackwelder.

Eoorthis kayseri (Walcott).

Plate 4, Figures 8, 8*a–b*.

Orthis (Plectorthis) kayseri WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXVIII, p. 266. (Characterized as below as a new species.)

Eoorthis kayseri (WALCOTT), 1912, Monogr. U. S. Geol. Survey, vol. LI, p. 782, plate XCVII, figs. 6, 6*a–b*. (Copy of the preceding reference.)

This is a larger shell than *Eoorthis linnarssoni* [p. 83], with which it is associated. Its surface is marked by numerous fine, radiating striæ, four or five in a distance of 1 mm.; and the inner layers of the shell appear to be minutely punctate. The ventral valve is more convex than the dorsal, the latter being nearly flat in young shells. Nothing is known of the interior except one cast of the pseudo-spondylium of the dorsal valve, which is larger in proportion than that of *E. linnarssoni*.

The largest ventral valve has a length of 14 mm.; width, 20 mm.

This species belongs in the group of *Eoorthis* represented by *E. desmopleura* (Meek) [Walcott, 1912*b*, plate XCVI, figs. 1, 1*a–r*] and *E. linnarssoni* [p. 83].

The species is named after Dr. Emanuel Kayser.

Formation and Locality.—Upper Cambrian: (C64) Upper limestone member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 42 (first list of fossils), and fig. 10 (bed 20), p. 38], 2.7 miles (4.3 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung, China; also (C68), upper part of the Ch'au-mi-tién limestone [idem, p. 36 (part of third list of fossils)], on crest of ridge east of Ch'au-mi-tién, 200 yards (183 m.) north of the wayside shrine, Ch'ang-hia district, Shan-tung, and (C74) a dense blue dolomitic limestone at the top of the Ki-chóu limestones [Willis and Blackwelder, 1907, pp. 139 and 145 (fifth list of fossils)], 4 miles (6.4 km.) east of Fang-lan-chön, Shan-si, China.

Collected by Eliot Blackwelder.

Eoorthis kichouensis (Walcott).

Plate 4, Figure 10.

Orthis (Plectorthis) kichouensis WALCOTT, 1906, Proc. U. S. Nat. Mus., vol. XXX, p. 570. (Described as below as a new species.)

Eoorthis kichouensis (WALCOTT), 1912, Monogr. U. S. Geol. Survey. vol. LI, p. 782, plate LXXXIX, fig. 5. (Copy of the preceding reference.)

This species is represented by a specimen of the dorsal valve. The outline of the shell is transversely rounded subquadrilateral; length, 9 mm.; width, 13 mm.; the highest point above the plane of the margin is about 3 mm. above the hinge-line; a shallow median sinus begins at the umbo, and gradually widens toward the front margin; back of the umbo the shell extends beyond the hinge-line, and then recedes to the beak, which apparently is at or a little over the upper edge of a very narrow area.

Surface marked by numerous radiating, rounded ribs, with narrow interspaces, seven ribs in a distance of 45 mm.; a few bifurcations of the ribs occur at irregular intervals between the apex and the margins. There are no traces of concentric striæ; if on the shell originally, they have been removed by the wearing off of the outer surface.

This species is distinguished from all other species by the strong, incurved umbo, and rounded ribs with narrow interspaces.

Formation and Locality.—Middle Cambrian: (C75) Limestone near the base of the Ki-chóu formation [Willis and Blackwelder, 1907, p. 143], 4.5 miles (7.2 km.) south of Wu-t'ai-hién, Shan-si, China.

Collected by Eliot Blackwelder.

Eoorthis linnarssoni (Kayser).

Plate 4, Figures 11, 11*a*.

Orthis linnarssoni KAYSER, 1883, China, Richthofen, vol. IV, p. 34, plate III, fig. 1. (Described and discussed in German as a new species; see below for translation. Fig. 1 is reproduced by Walcott, 1911, plate XCVII, fig. 5*a*.)

Orthis (Plectorthis) linnarssoni (Kayser), WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXVIII, p. 266. (Original description copied and species discussed as below.)

Eoorthis linnarssoni (Kayser), WALCOTT, 1912, Monogr. U.S. Geol. Survey, vol. LI, pp. 782–783, plate XCVII, figs. 5, 5*a*. (Copy of the preceding reference.)

The original description by Kayser follows:

"Shell semielliptical in outline, broader than long, with hinge edge straight, corresponding to the greatest breadth of the shell. Large (ventral) valve moderately convex. Small (dorsal) valve slightly arched, with a sinus which develops at the umbo, and grows quite broad and deep toward the edge. Umbo of ventral valve small, area very low. Surface of shell covered with rather sharp ribs, exceedingly variable in strength, separated by narrow furrows. By reason of repeated splitting, which begins close to the umbo, the ribs appear more like bundles of ribs. On the matrix these bundles appear as broad, obtuse-angled folds, which, owing to repeated marginal splitting in even a higher degree than on the shell itself, appear as bundles of ribs of very unlike strength. When the surface is well preserved, a delicate concentric growth striation is perceptible."

Doctor Kayser compares this shell with *Billingsella hicksi* (Salter) [Walcott, 1912*b*, plate XCVII, figs. 7, 7*a–b*] and *Billingsella exporrecta* (Linnarsson) [idem, plate LXXXVIII, figs. 1, 1*a–l*], on account of the surface characters. It does not appear to be very closely related to either species, but it is in many respects allied to *Eoorthis desmopleura* (Meek) [idem, plate XCVI, figs. 1, 1*a–r*] and *E. wichitaensis* (Walcott) [idem, plate XCIV, figs. 1, 1*a–o*, 1*u*]. *Eoorthis linnarssoni* differs from both in being more transverse. This species is represented by a dorsal valve, illustrated by figure 11, from near Yen-chuang.

Formation and Locality.—Upper Cambrian: (C64) Upper limestone member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 42 (first list of fossils), and fig. 10 (bed 20), p. 38], 2.7 miles (4.3 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Another dorsal valve that is very closely related to, if not identical with this species, occurs in stream gravels at Locality C67, Upper Cambrian: stream gravels (these are taken from the wash from the mountains south of the city) used in making the railroad grade one-third mile (0.5 km.) west of the west city gate at Tsi-nan, Shan-tung, China.

Collected by Eliot Blackwelder.

Eoorthis pagoda (Walcott).

Plate 4, Figures 12, 12*a–d*.

Orthis (Plectorthis) pagoda WALCOTT, 1905, Proc. U.S. Nat. Mus., vol. XXVIII, pp. 267–268. (Described and discussed as on page 84 as a new species.)

Eoorthis pagoda (WALCOTT), 1912, Monogr. U. S. Geol. Survey, vol. LI, pp. 784–785, plate XCVII, figs. 12, 12*a–d*. (Copy of the preceding reference.)

Shell transverse, subsemicircular; a ventral valve 11 mm. in length has a width of 15 mm., and a dorsal valve 8 mm. in length has a width of 13 mm.; hinge-line a little shorter than the greatest width of the shell; cardinal angles vary from 75° to 111°; valves moderately convex. Cardinal area narrow in both valves and inclined backward from the hinge-line. Surface marked by equidistant, narrow, low ribs, three in a space of 2 mm. near the front margin of a shell 10 mm. long, with fine, radiating striæ between them; the radiating ribs and striæ are crossed by fine concentric striæ and lines of growth.

Ventral valve with a strong, somewhat angular median fold, rising from a well-defined depression on each side of it, or it might be designated as a very strong rib rising above the general surface of the valve from a broad median depression; the lateral slopes are gently convex. Dorsal valve with a strong, angular median depression, beginning at the posterior margin and gradually widening to the front; the sides of the depression rise above the general surface of the valve and form with the outer slope a well-defined, low ridge on each side that extends a little forward on the front margin to fit into the depressions on each side of the median fold of the ventral valve.

The interior of a small dorsal valve has a broad, strong median ridge corresponding to the depression on the exterior surface; a main vascular sinus starts on each side of the base of the median ridge and arches outward and then forward about a depressed oval space on each side of the ridge; lateral branches extend from the main sinus toward the sides; the impressions of the anterior and posterior adductor muscle scars occur on the slopes of the median ridge and the oval depressions; somewhat obscure radiating lines mark the anterior portion of the surface.

This shell is distinguished by its strongly marked median ridge on the ventral valve and sinus on the dorsal valve. In general form and surface markings it is not unlike *Eoorthis desmopleura* (Meek) [Walcott, 1912*b*, plate XCVI, figs. 1, 1*a–r*] and *Eoorthis wichitaensis* (Walcott) [idem, plate XCIV, figs. 1, 1*a–o*, 1*u*].

Formation and Locality.—Upper Cambrian: Lower part of Ch'au-mi-tién limestone [Blackwelder, 1907*a*, p. 42 (part of last list of fossils)], (C54) near top of limestone knoll two-thirds of a mile (1.1 km.) west of Tsi-nan, and (C56) 25 feet (7.5 m.) below the top of Pagoda Hill, 1 mile (1.6 km.) west of Tsi-nan, Shan-tung, China.

Collected by Eliot Blackwelder and Li San.

Eoorthis sp. undt. (*a*) (Walcott).

Plate 4, Figure 13.

Orthis (*Plectorthis*) sp. undt. WALCOTT, 1906, Proc. U. S. Nat. Mus., vol. XXX, p. 571. (Described and discussed essentially as below.)

Eoorthis sp. undt. *c* (WALCOTT), 1912, Monogr. U. S. Geol. Survey, vol. LI, p. 793, plate LXXXIX, fig. 7. (A copy of the preceding reference.)

This species is represented by a single specimen of the ventral valve. Ventral valve convex, with the apex curving gently downward from the highest point to the cardinal area; transverse length, 2.5 mm.; width, 3 mm.; hinge-line a little shorter than the greatest width; cardinal area sloping slightly backward from the hinge-line.

Surface marked by about sixteen strong, nearly regular, rounded, radiating ribs, that are crossed by fine, concentric striæ, lines of growth, and one strong ridge indicating interruption of growth.

This little shell was at first placed with *Eoorthis agreste* [p. 81], but further study showed that its greater convexity, elevated apex, and stronger ribs distinguish it from that species.

Formation and Locality.—Middle Cambrian: (C26) Near the top of the black oolitic group in the uppermost layers of the Ch'ang-hia limestone [Blackwelder,

1907*a*, p. 33 (part of the last list of fossils)], 2 miles (3.2 km.) north-northeast of Ch'ang-hia, Shan-tung, China.

Collected by Eliot Blackwelder.

Eoorthis sp. undt. (*b*) (Walcott).[1]

Plate 4, Figure 9.

Eoorthis sp. undt. *d* (WALCOTT), 1912, Monogr. U. S. Geol. Survey, vol. LI, p. 793, plate LXXXIX, fig. 8. (Described and discussed as below.)

A larger shell of this type [see plate IV, fig. 9] occurs in Shan-si, in the central portion of the Ki-chóu formation. It has a length of 6.5 mm. and a width of 7.5 mm. The surface is marked by numerous radiating ribs, similar to those of the shell from Ch'ang-hia, also concentric striæ and several ridges resulting from interruption of growth.

Formation and Locality.—Middle Cambrian: (C 71) Massive cliff-making limestone in the central portion of the Ki-chóu formation [Willis and Blackwelder, 1907, pp. 139 and 145 (second list of fossils)], 4 miles (6.4 km.) southwest of Tung-yü, Shan-si, China.

Collected by Bailey Willis and Eliot Blackwelder.

Genus HUENELLA Walcott.

For discussion of the genus *Huenella* see Monogr. U. S. Geol. Survey, vol. LI, 1912, p. 805.

Huenella orientalis (Walcott).

Plate 4, Figures 14, 14*a–b*.

Syntrophia orientalis WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXVIII, p. 292. (Characterized and discussed as below as a new species.)

Huenella orientalis (WALCOTT), 1912, Monogr. U. S. Geol. Survey, p. 808, plate CIV, figs. 3, 3*a–b*. (Copy of the preceding reference.)

This species is closely related in form and surface characters to *Huenella texana* (Walcott) [1912*b*, p. 808, plate CIII, figs. 1, 1*a–i*] and some forms of *H. abnormis* (Walcott) [idem, pp. 805–806, text fig. 13, p. 299, and plate CIII, figs. 2, 2*a–m*]. It differs from them in details of surface ribs. On the dorsal valve there are two or three faintly defined, radiating ribs on each side of the median fold, which has obscure ribs upon it. Corresponding ribs occur upon the mesial depression of the ventral valve and the side slopes adjoining the depression. The material representing it is too limited to warrant an identification with any described species. *Huenella orientalis* is the trans-Pacific representative of *H. texana* (Walcott).

Formation and Locality.—Upper Cambrian: (C 64) Upper limestone member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 42 (first list of fossils), and fig. 10 (bed 20), p. 38], 2.7 miles (4.3 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Genus SYNTROPHIA Hall and Clarke.

For discussion of the genus *Syntrophia* see Monogr. U. S. Geol. Survey, vol. LI, 1912, pp. 798–799.

Syntrophia orthia Walcott.

Plate 5, Figures 1, 1*a–b*.

Syntrophia orthia WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, pp. 11–12. (Described and discussed as a new species essentially as on page 86.)

Syntrophia orthia WALCOTT, 1912, Monogr. U. S. Geol. Survey, vol. LI, p. 803, plate CIV, figs. 4, 4*a–b*. (Copy of the preceding reference.)

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[1]See synonymy for *Eoorthis* sp. undt. (*a*), p. 84.

General form irregularly oval, with the ventral view obtusely angular toward the apex; rounded, biconvex, with a deep mesial sinus on the ventral valve and a strong median fold on the anterior half of the dorsal valve.

Surface smooth, with the exception of a few concentric striæ and lines of growth.

The ventral valve has a strong median sinus that occupies about one-third of the width of the valve at the anterior margin and projects forward to fit into the fold in the front of the margin of the dorsal valve; the sides of the median sinus are elevated, and, with the downward curving lateral slopes, form a strong rounded ridge on each side of the sinus; none of the specimens in the collection shows the area, but from the profile of the valve it must have been of moderate height, with a rather sharp apex curving over it.

Dorsal valve with a minute apex from which a narrow, slightly developed median fold extends out to about the center of the shell, where it becomes elevated and projects forward to the front margin; the remaining portions of the surface are uniformly convex, sloping away from the median fold to the margins of the valve.

Nothing is known of the interior of either valve.

In general form this species resembles *Syntrophia primordialis* (Whitfield) [Walcott, 1912*b*, plate CII, figs. 2, 2*a*–*e*] of the St. Croix sandstone of Wisconsin. It differs in its more rounded, irregularly oval form and the very large median sinus of the ventral valve.

Formation and Locality.—Upper Cambrian: Lower part of Ch'au-mi-tién limestone [Blackwelder, 1907*a*, p. 42 (part of last list of fossils)], (C56) 25 feet (7.5 m.) below the top of Pagoda Hill, 1 mile (1.6 km.) west of Tsi-nan, and (C54) near top of limestone knoll two-thirds of a mile (1.1 km.) west of Tsi-nan, Shan-tung; also (C64), upper limestone member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 42 (first list of fossils), and fig. 10 (bed 20), p. 38], 2.7 miles (4.3 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Collected by Eliot Blackwelder and Li San.

GASTROPODA.

Genus SCENELLA Billings.

Scenella clotho Walcott.

Plate 5, Figures 3, 3*a*.

Scenella clotho WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 12. (Described and discussed as a new species essentially as below.)

Shell small, moderately convex; apex elongate, slightly eccentric, elevated; aperture irregularly oval; a narrow carina extends from the apex down to the broader end, and several obscure carinæ radiate from the apex toward the margin.

Surface marked by fine concentric striæ and very fine radiating striæ.

The type specimen has a length of 4.25 mm.; greatest width, 3 mm.; elevation of apex, about 1.5 mm.

This species is clearly distinguished by the broad, elliptical, or subovate form of its aperture, and elongated apex; the latter feature is determined from the interior of the shell, which indicates that the apex was situated somewhat near the narrower end of the aperture; this feature suggests that if there were perfect specimens representing the species, it might be found to be more nearly related to some forms of *Stenotheca* than to *Scenella*.

Formation and Locality.—Middle Cambrian: (C18) Dark gray oolitic limestone about 400 feet (120 m.) above the base of the Ch'ang-hia limestone [Blackwelder, 1907*a*, p. 33 (third list of fossils)], in cliffs 1 mile (1.6 km.) east of Ch'ang-hia, Shan-tung, China.

Collected by Eliot Blackwelder.

Scenella ? dilatatus Walcott.

Plate 5, Figures 2, 2*a*.

Scenella ? dilatatus WALCOTT, 1906, Proc. U. S. Nat. Mus., vol. XXX, p. 570. (Described and discussed as a new species essentially as below.)

This species is based upon two specimens which preserve the expanded outer margin, but not the elevated, central, conical portion of the shell. The exterior outline is oval, the length of the type specimen being 9 mm.; width, 7 mm. The surface on the inner side of the campanulate margin is marked by numerous radiating, elevated striæ. As viewed from the lower side the margin slopes gently inward to a shallow depression, or furrow, within which there is a rounded, slightly elevated ridge, that extends around the border of the elevated portion of the shell, except on what is supposed to be the posterior side; on this side the curvature from the margin across the border to the elevated portion of the shell is uninterrupted.

A second specimen occurs in the collection which shows the exterior surface. This is smooth, and corresponds in surface configuration approximately to the reverse of the specimen above described. Unfortunately it is in a very fragmentary state, neither the outline of the margin nor the central, elevated portion being preserved.

This species is distinguished by the broad, campanulate-like border; it differs from *Scenella clotho* [p. 86] in its smooth exterior surface and the strong, radiating striæ on the inner surface, both the outside and inside of the shell of *S. clotho* being marked by concentric striæ and lines of growth.

Formation and Locality.—Middle Cambrian: (C 70) Oolitic limestone about 30 feet (9 m.) above the base of the Ki-chóu limestone [Willis and Blackwelder, 1907, p. 144 (last list of fossils)], 4 miles (6.4 km.) south-southwest of Tung-yü, Shan-si, China.

Collected by Eliot Blackwelder.

Scenella sp. undt. Walcott.

Plate 5, Figure 4.

Scenella sp. undt. WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 12. (Discussed as below.)

This species is represented by a cast of the interior of a small patelloid shell, with an oval aperture measuring 2 by 3 mm., and having a slightly eccentric, elevated apex. It does not appear to be identical with *Scenella clotho* [p. 86] of the Ch'ang-hia formation, as the apex is more eccentric and there is no evidence of any carina. In outline it is much like *Scenella ? conula* Walcott [1884*b*, p. 15, plate 9, fig. 6], but it differs in surface characters and the form of its margin.

Formation and Locality.—Upper Cambrian: (C 56) Lower part of Ch'au-mi-tién limestone, 25 feet (7.5 m.) below the top of Pagoda Hill [Blackwelder, 1907*a*, p. 42 (part of last list of fossils)], 1 mile (1.6 km.) west of Tsi-nan, Shan-tung, China.

Collected by Eliot Blackwelder and Li San.

Genus MATHERELLA Walcott.

Matherella WALCOTT, 1912, Smithsonian Misc. Coll., vol. 57, No. 9, p. 263. (Described and discussed as a new genus.)

Univalve shells, sinistrally coiled; spine composed of rounded volutions that are more or less elevated; umbilicus open; peristome, as far as known, entire, united with the preceding volution on the inner side, and probably not expanded to any considerable extent.

Genotype.—*Matherella saratogensis* Walcott [1912*a*, p. 264].

The species *Straparollina circe* Walcott is referred to *Matherella* with considerable doubt, but as it is a sinistrally coiled shell with an open umbilicus, rounded whorls, and apparently with a relatively small aperture and narrow peristome, it is placed in the genus.

Matherella circe (Walcott).

Plate 5, Figure 5.

Straparollina circe WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 13. (Described and discussed as a new species essentially as below.)

Shell small, hemispherical, spire depressed and rounded in outline; whorls probably about three; only two are preserved; suture shallow; the whorls are gently and uniformly rounded from the suture down to the more rapid curve to the basal side; as far as can be determined a section of the outer whorl has the form of an ellipse, the narrower parts toward the dorsal furrow and the outer basal margin.

The surface is marked by concentric, elevated lines that extend obliquely backward from the dorsal furrow to the base of the whorl, where they are concealed by the matrix.

The greatest diameter of the type and only specimen is 3.5 mm.; greatest diameter near aperture, 2 mm.; diameter of whorl opposite aperture, 1.5 mm.

This species differs from *Straparollina remota* Billings[1] in the more rapid expansion of the outer whorl and more elevated spire and in having a sinistrally coiled shell.

Formation and Locality.—Upper Cambrian: (C56) Lower part of Ch'au-mi-tién limestone, 25 feet (7.5 m.) below the top of Pagoda Hill [Blackwelder, 1907*a*, p. 42 (part of last list of fossils)], 1 mile (1.6 km.) west of Tsi-nan, Shan-tung, China.

Collected by Eliot Blackwelder and Li San.

Genus STRAPAROLLINA Billings.

Straparollina sp. undt. Walcott.

Plate 5, Figure 6.

Straparollina sp. undt. WALCOTT, 1905, Proc. U.S. Nat. Mus., vol. XXIX, p. 13. (Species discussed as below.)

This form is represented by the lower portion of a single whorl, that is rounded in outline and suggestive of *Straparollina remota* Billings [1872, p. 471]. The greatest diameter across the volution is 6.5 mm., and of the whorl, 2.5 to 3 mm.

Formation and Locality.—Middle Cambrian: (C55) Just below the Ch'au-mi-tién limestone in the Ku-shan shales [Blackwelder, 1907*a*, p. 43], in isolated hills at an elevation of 380 feet (114 m.) above the Wön-ho, 12 miles (19 km.) south 80° east of Tsi-nan, Shan-tung, China.

Collected by Bailey Willis and Eliot Blackwelder.

Genus PELAGIELLA Matthew.

Pelagiella chronus (Walcott).

Plate 5, Figures 9, 9*a*–*b*.

Platyceras chronus WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 14. (Described and discussed as a new species essentially as below.)

Shell minute, consisting of two whorls somewhat irregularly incurved, the inner whorl being on the plane of the dorsal (outer) side; the outer whorl expands rapidly toward the aperture, increasing more on the right ventral (inner) side; a cross-section of the outer whorl shows the outer side to be slightly convex and the inner side strongly convex, a rather sharp dorsal angle being formed where the two unite on the outer side.

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[1]Canadian Naturalist and Geologist, vol. VI, 1872, p. 471, fig. 7.

A narrow, sharp ridge occurs about midway of the outer side of the whorl, that is seen only when the outer surface is very perfectly preserved; in one example the ridge has a narrow depression on the outer side, which makes a rather prominent feature of the surface; the striæ of growth arch backward to this ridge, indicating a sharp but small dorsal sinuosity in the peristome; on casts of the interior neither the ridge nor the arching backward of the striæ is shown.

The surface of finely preserved specimens is marked by concentric lines of growth, a sharp ridge, and one or two very fine elevated lines subparallel to the ridge.

Greatest diameter of shell, 1.5 mm.; dorso-ventral diameter of whorl at aperture, 0.75 mm.; lateral diameter, 0.5 mm.

This species appears to be most nearly related to *Platyceras primævum* Billings [1871, p. 220]. It differs in its stronger dorsal angle and more rapidly expanding outer whorl.

Formation and Locality.—Middle Cambrian: (C1) Lower shale member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 40 (part of the third list of fossils), and fig. 10 (bed 4), p. 38], 2 miles (3.2 km.) south of Yen-chuang, and (C4) limestone nodules at the base of the lower shale member of the Kiu-lung group [idem (second list of fossils), and fig. 10 (bed 4), p. 38], 3 miles (4.8 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung; also (C18), dark gray oolitic limestone about 400 feet (120 m.) above the base of the Ch'ang-hia limestone [idem, p. 33 (third list of fossils)], in cliffs 1 mile (1.6 km.) east of Ch'ang-hia, Shan-tung, China.

Collected by Eliot Blackwelder.

Pelagiella clytia (Walcott).

Plate 5, Figure 14.

Platyceras clytia Walcott, 1905, Proc. U. S. Nat. Mus., vol. xxix, p. 14. (Described and discussed as a new species essentially as below.)

Shell minute, consisting of about two whorls. Whorls regularly incurved, the plane of the coiling being nearly perfect, with the exception of a very slight inclination to the left when looking down upon it from above (dorsally); outer whorl very minute at origin, increasing slightly for the first half of its turn and then rapidly toward the aperture, which is rounded ovate, being narrowest at the dorsum; a rounded dorsal ridge is formed on the outer whorl by the convex slope of the two sides meeting at the dorsum.

Surface apparently smooth in the half dozen specimens in the collection.

Greatest diameter, 2.75 mm.; dorso-ventral diameter of whorl near aperture 1.5 mm.; greatest lateral diameter, 1.25 mm.

This species differs from *Pelagiella chronus* [p. 88] and *P. pagoda* in the form of the outer whorl, which expands more uniformly and has a broadly ovate section; its form also distinguishes it from *Platyceras primævum* Billings [1871, p. 220].

Formation and Locality.—Upper Cambrian: (C47) Upper part of the Ch'au-mi-tién limestone [Blackwelder, 1907*a*, fig. 9 (top of bed 1), p. 35], at the top of a high col at Ch'au-mi-tién, Shan-tung, China.

Collected by Eliot Blackwelder.

Pelagiella pagoda (Walcott).

Plate 5, Figures 10, 10*a*.

Platyceras pagoda Walcott, 1905, Proc. U. S. Nat. Mus., vol. xxix, p. 15. (Described and discussed as a new species essentially as below.)

Shell minute, consisting of about two whorls, of which the inner whorl is very small and incurved so as to be seen best from the right dorsal or outer side. Whorls

regularly incurved, with the plane of the coiling toward the right dorsal side. The section of the outer whorl near the aperture is elongate oval, with the left ventral side somewhat flattened. The outer whorl widens rapidly toward the aperture, especially on the right ventral (inner) side, which gives the outline, when looked at from the dorsal ridge, an oblique, unsymmetrical appearance.

Surface marked by concentric lines of growth which arch backward upon the dorsum, indicating a dorsal sinuosity in the peristome.

Greatest diameter of the shell, 2.5 mm.; dorso-ventral diameter of whorl near the aperture, 1.75 mm.; greatest lateral diameter not measurable, but apparently not more than one-half the antero-posterior diameter.

This species differs from *Pelagiella chronus* [p. 88] in the size of the outer whorl, minute inner whorl, and the absence of longitudinal ridges, features which also distinguish it from *Platyceras primævum* Billings [1871, p. 220] and allied forms.

Formation and Locality.—Upper Cambrian: (C56) Lower part of Ch'au-mi-tién limestone, 25 feet (7.5 m.) below the top of Pagoda Hill [Blackwelder, 1907*a*, p. 42 (part of last list of fossils)], 1 mile (1.6 km.) west of Tsi-nan, Shan-tung, China.

Collected by Eliot Blackwelder and Li San.

Pelagiella willisi (Walcott).

Plate 5, Figures 12, 13.

Platyceras willisi Walcott, 1906, Proc. U. S. Nat. Mus., vol. xxx, p. 572. (Described and discussed as a new species essentially as below.)

Shell minute, consisting of two whorls somewhat irregularly incurved; the apex and one side of the aperture lie in the same plane; the outer whorl increases in size gradually through its first half, and then expands more rapidly toward the aperture; a cross-section of the outer whorl shows the dorsal (outer) side to be gently convex and the inner side somewhat more strongly convex, a rounded dorsal angle being formed where the two sides unite on the outer edge.

The surface is marked by concentric lines of growth parallel to the aperture.

The greatest diameter of the largest shell is 1.6 mm.

This species differs from *Pelagiella chronus* [p. 88] in having a more slender, rounded outer whorl, without trace of the dorsal ridge characteristic of that species. It differs from *P. clytia* [p. 89] in being coiled on the plane of the dorsal side instead of on the plane of the median line.

Formation and Locality.—Middle Cambrian: (C72) Thin green-gray limestone interbedded with ocherous and green clay shales, overlying the massive oolite in the Ki-chóu formation [Willis and Blackwelder, 1907, pp. 139 and 145 (third list of fossils)], 4 miles (6.4 km.) east of Fang-lan-chön, Shan-si, China.

Collected by Eliot Blackwelder.

Genus HELCIONELLA Grabau and Shimer.

Helcionella Grabau and Shimer, 1909, North American Index Fossils, vol. iii, p. 607.

Helcionella ? clurius (Walcott).

Plate 5, Figure 7.

Stenotheca clurius Walcott, 1905, Proc. U. S. Nat. Mus., vol. xxix, p. 15. (Described and discussed as a new species essentially as below.)

This form is represented by the interior cast of a large, slender, slightly curving shell. The cast has a length of 16 mm., with a diameter where it is broken off at

the end of 4 by 5 mm. The largest diameter at the aperture was probably about 10 mm.

The generic reference of this specimen is doubtful, but in the absence of the outer shell it is not possible to determine the generic relations.

Formation and Locality.—Upper Cambrian: (C 46) Light gray, crystalline limestone on the Ch'ang-hia limestone [Blackwelder, 1907*a*, p. 33 (fourth list of fossils)], at Ch'au-mi-tién, Shan-tung, China.

Collected by Eliot Blackwelder.

Helcionella rugosa chinensis (Walcott).

Plate 5, Figure 8.

Stenotheca rugosa chinensis WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 16. (Described and discussed as a new species essentially as below.)

In its general form this shell is closely related to *Helcionella rugosa;* it is, however, more elevated and more broadly oval in outline than the typical forms of *H. rugosa.* The surface is marked by a number of moderate undulations, or low, concentric ridges, and numerous very fine, concentric striæ of growth; with a strong lens fine radiating striæ are visible.

The type and only specimen in the collection has a longer diameter at the aperture of about 10 mm., with a height of 7 mm. to where the apex is decorticated; at this point the oval section has a length of 2.5 mm., with a width of 1.5 mm. The apex is broken off at a smooth, slightly convex septum.

This specimen is of unusual interest, owing to the presence of a septum toward the apex. In form it resembles most closely *H. rugosa acutacosta* (Walcott) [1891*a*, p. 617, plate 74, figs. 2, 2*a*–*b*], but differs from that variety in the presence of rounded instead of acute costæ. From *H. rugosa* it differs in being elevated and more or less conical.

Formation and Locality.—Lower Cambrian: (C3) Lower part of the Man-t'o shale formation [Blackwelder, 1907*a*, p. 28 (list of fossils at bottom of page), and fig. 8*a* (bed 20), p. 28], on the southeast slope of Hu-lu-shan, 2.5 miles (4 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Collected by Eliot Blackwelder.

Helcionella rugosa orientalis (Walcott).

Plate 5, Figures 15, 15*a*.

Stenotheca rugosa orientalis WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 16. (Described and discussed as a new species essentially as below.)

This variety is founded upon a small, slender shell with a rounded, oval aperture. In form it is between *Helcionella rugosa acutacosta* (Walcott) [1891*a*, p. 617, plate 74, figs. 2, 2*a*–*b*] and *H. rugosa erecta* Walcott [idem, fig. 4], being slender, slightly arched, and cornucopia-like. Surface marked by strong, sharply angular, concentric ridges, with broader U-shaped furrows between them, and numerous fine concentric striæ. The average length of the shells of this species is 3 mm., with a diameter at the aperture of 1.5 to 1.75 mm.

Formation and Locality.—Middle Cambrian: (C21) Ocher-mottled phase of purple-gray limestone in the middle of the oolitic Ch'ang-hia formation [Blackwelder, 1907*a*, p. 33 (second list of fossils)], at Ch'ang-hia, and (C18) dark gray oolitic limestone about 400 feet (120 m.) above the base of the Ch'ang-hia limestone [idem (third list of fossils)], in cliffs 1 mile (1.6 km.) east of Ch'ang-hia, Shan-tung, China.

Collected by Eliot Blackwelder.

Helcionella ? ? simplex (Walcott).

Plate 5, Figure 11.

Stenotheca simplex WALCOTT, 1906, Proc. U. S. Nat. Mus., vol. XXX, p. 573. (Described and discussed as a new species essentially as below.)

Shell small, depressed conical, with the apex situated about one-sixth the distance from the front to the posterior margin; the point of the apex is broken away; aperture subcircular, a little broader than long.

Surface with fine concentric striæ and lines of growth and a few fine radiating lines. There is a trace of a shallow furrow extending from the apex toward the central portion of the anterior margin.

The greatest diameter of the type and only specimen is 2 mm.

This species differs widely from other known species from China. It may be compared with some varieties of the young of *Helcionella rugosa*, but it differs in the aperture being broader and in not having a rugose surface. The continuous concentric striæ and absence of an area indicate that it is probably a gastropod, but its generic reference is doubtful. The flattened space or shallow median furrow suggests a brachiopod allied to *Acrotreta*, but the calcareous shell is not in accord with that interpretation.

Formation and Locality.—Middle Cambrian: (C70) Oolitic limestone about 30 feet (9 m.) above the base of the Ki-chóu limestone [Willis and Blackwelder, 1907, p. 144 (last list of fossils)], 4 miles (6.4 km.) south-southwest of Tung-yü, Shan-si, China.

Collected by Eliot Blackwelder.

PTEROPODA.

Genus HYOLITHES Eichwald.

Hyolithes cybele Walcott.

Plate 5, Figures 16, 16*a–c*; Plate 6, Figure 7.

Hyolithes cybele WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 17. (Described and discussed as a new species essentially as below.)

Form an elongate, subtriangular pyramid, gradually and regularly tapering to an acute extremity. The apical angle of the dorsal side is about 15°. Transverse section rounded subtriangular; the ventral angle is rounded and the lateral angles are slightly rounded off. Dorsal face moderately convex and curving very slightly from the apex to the anterior spatulate portion. Ventral face strongly and regularly convex transversely. Aperture oblique, the margin extending on the dorsal side; the peristome on the ventral side is slightly curved forward.

Surface marked by concentric, transverse, more or less obscure lines and striæ of growth; the cast of the interior shows on the ventral face three or four obscure longitudinal lines, the central one of which is the strongest.

The largest specimen in the collection has a length of 24 mm., with a width of 7 mm. at the aperture.

The body of the associated operculum is semicircular, moderately convex on the outer side externally, and concave within. The ventral wing as seen on the outside is semicircular-convex, rising toward a point at the center of the transverse side. The dorsal limb is nearly flat, rising, as far as can be determined from a broken specimen, at an angle of about 100° from the plane of the body of the operculum.

In the slope of the sides toward the apex, character of surface, and the transverse section this species may be compared with *Hyolithes princeps* Billings [Walcott, 1891*a*, p. 621, plate 76, figs. 1, 1*a–l*] of the Lower Cambrian of Newfoundland, *H. tenuistriatus* Linnarsson [1871*b*, p. 792, plate 16, figs. 4–9] and *H. arenophilus* Holm [1893, p. 71, plate 1, figs. 78–81; plate 2, figs. 1–2]. *Hyolithes cybele* is, however, much smaller than the first two species mentioned, and its section is much more convex, both on the dorsal and ventral sides, than that of *H. arenophilus* Holm.

Formation and Locality.—Middle Cambrian: (C1 and C2) Lower shale member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 40 (part of the third list of fossils), and fig. 10 (bed 4), p. 38], 2 miles (3.2 km.) south of Yen-chuang, Sin-t'ai district, Shan-tung, and (C62) earthy layer in the middle limestone of the Kiu-lung group [idem (last list of fossils), and fig. 10 (base of bed 7), p. 38], 2.5 miles (4 km.) south of Yen-chuang, on the north-northeast spur of Hu-lu-shan, Sin-t'ai district, Shan-tung; also (C4), limestone nodules at the base of the lower shale member of the Kiu-lung group [idem (second list of fossils), and fig. 10 (bed 4), p. 38], 3 miles (4.8 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung, and (C22) Ch'ang-hia limestone in upper oolitic portion [idem, pp. 22 and 33 (part of last list of fossils)], at Ch'ang-hia, Shan-tung, China.

Collected by Eliot Blackwelder [with exception of (C62), collected by Li San].

In Manchuria beautifully preserved specimens of *H. cybele* occur in a limestone associated with *Hyolithes glaber* Walcott.

Formation and Locality.—Middle Cambrian: (35n and 35r) Fu-chóu series; limestones near the base of the series just above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general section giving stratigraphic relations]; collected in a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria, China.

Collected by J. P. Iddings and Li San.

Hyolithes daphnis Walcott.

Plate 5, Figure 17.

Hyolithes daphnis WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 18. (Described and discussed as a new species essentially as below.)

The type and only specimen of this species in the collection has a length of 26 mm., with a width at the larger end on the dorsal side of 11 mm., and a dorso-ventral thickness of 9 mm. At a distance of 21 mm. from the larger end the smaller end has a width of 5 mm. on the dorsal side. Nothing is known of the outer surface. The section shows a very strongly convex ventral side, with rounded ventral angle; the dorsal side is gently convex, with the lateral angle slightly rounded.

This species is represented by a cast that might have been taken from some of the more convex specimens of *Hyolithes princeps* Billings,[1] of the Lower Cambrian rocks of Newfoundland. It differs from these in the more convex dorsal side.

Formation and Locality.—Middle Cambrian: (C64) Upper limestone member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 42 (first list of fossils), and fig. 10 (bed 20), p. 38], 2.7 miles (4.3 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Collected by Eliot Blackwelder.

[1]Tenth Ann. Rept. U. S. Geol. Survey, 1890, p. 621, plate 76, figs. 1, 1*a–l*.

Hyolithes delia Walcott.

Plate 5, Figure 18.

Hyolithes delia WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 18. (Described and discussed as a new species essentially as below.)

This species is represented by the dorsal side of a single specimen. It resembles the dorsal side of *Hyolithes billingsi* Walcott [1886, p. 134, plate 13, figs. 1*b*, 1*e*]. The dorsal surface is gently convex and is marked on each side, parallel to and a little distance within the margin, by a very shallow groove which outlines a central, more slightly convex area. The specimen is probably the interior cast. It shows a few forward-arching, concentric lines of growth.

The type and only specimen representing the species has a length of 5 mm., with a width of 1 mm. at the smaller end and 2.25 mm. at the larger end.

From the means of comparison afforded by the single specimen this species appears to be most closely related to *Hyolithes billingsi*. It differs in the more slender tube.

Formation and Locality.—Lower Cambrian: (C3) Lower part of the Man-t'o shale formation [Blackwelder, 1907*a*, p. 28 (list of fossils at bottom of page), and fig. 8*a* (bed 20), p. 38], on the southeast slope of Hu-lu-shan, 2.5 miles (4 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Collected by Eliot Blackwelder.

Hyolithes sp. undt.

Plate 5, Figures 19, 20.

This species is represented by a fragment of what appears to be the aperture of a species of *Hyolithes*, having a rather rapidly tapering tube. It is barely possible that it is a crushed specimen of *Orthotheca doris* [plate 6, fig. 2].

Formation and Locality.—Lower Cambrian: (C32′) A limestone bowlder collected in river drift 1 mile (1.6 km.) south of Chön-p'ing-hién, on the Nan-kiang River, southern Shen-si, China.

Collected by Bailey Willis and Eliot Blackwelder.

An operculum of unknown specific relations is illustrated by figure 20, plate 5. It is from Locality C4, Middle Cambrian, limestone nodules at the base of the lower shale member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 40 (second list of fossils), and fig. 10 (bed 4), p. 38], 3 miles (4.8 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Collected by Eliot Blackwelder.

Genus ORTHOTHECA Novak.

Orthotheca cyrene Walcott.

Plate 5, Figures 21, 21*a*.

Orthotheca cyrene WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 18. (Described and discussed as a new species essentially as below.)

Form an elongate, slender, subtriangular tube, with the lateral margin rounded, tapering gradually from the base to an acute extremity. Transverse section rounded subtriangular, transverse and slightly concave toward the center on the dorsal side, rounded at the lateral angles, highly arched on the ventral side, with the ventral angle broadly rounded. Dorsal face of the lateral angles rounded, with a shallow depression, with rounded lateral slopes a little more than one-third the width of the face. Ventral face strongly and regularly convex transversely,

and without any ventral angle. Aperture, as far as known, transverse, at right angles to the axis of the shell. Operculum unknown. Shell of moderate thickness and made up apparently of several layers or lamellæ.

Surface of the shell concentrically or transversely finely striated; a few longitudinal striæ may be seen by turning the specimen in the light.

The largest specimen, which is broken off at the apical end, has a length of 9 mm., with a width on the dorsal side at the larger end of 2 mm.; a specimen with a diameter of 3 mm. on the dorsal face has a dorso-ventral diameter of 2 mm.

What appears to be a transverse septum occurs in one of the shells about 9 mm. from the apical end.

The elongate form of the tube and the shallow groove on the center of the dorsal face are not unlike *Orthotheca communis emmonsi* (Ford) [Walcott, 1891*a*, p. 621, plate 77, fig. 4*b*]. The two species, however, differ in the outline of the transverse section and in the more rapidly expanding tube of *Orthotheca cyrene*. There are a number of species from the Swedish Cambrian, illustrated by Holm, that have the central depression on the dorsal face. Of these, *Orthotheca affinis* Holm [1893, p. 60, plate 1, figs. 57–69; plate 5, figs. 59–63; plate 6, fig. 11] is most nearly related to *O. cyrene*.

Formation and Locality.—Upper Cambrian: (C47) Upper part of the Ch'au-mi-tién limestone [Blackwelder, 1907*a*, fig. 9 (top of bed 1), p. 35], at the top of a high col at Ch'au-mi-tién, Shan-tung, and (C64) upper limestone member of the Kiu-lung group [idem, pp. 37 and 42 (first list of fossils), and fig. 10 (bed 20), p. 38], 2.7 miles (4.3 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Collected by Eliot Blackwelder.

Two specimens of this species occur in limestone of the *Dorypyge richthofeni* zone in Manchuria.

Formation and Locality.—Middle Cambrian: (35n) Fu-chóu series; limestones near the base of the series just above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general section giving stratigraphic relations], collected in a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria, China.

Collected by J. P. Iddings and Li San.

Orthotheca cyrene dryas Walcott.

Plate 5, Figures 22, 22*a–c*.

Orthotheca cyrene dryas WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 19. (Characterized as a new variety as below.)

This variety is characterized by having a broader, more shallow furrow on the dorsal face; otherwise it appears to be identical with *O. cyrene* [p. 94]. On some specimens the shallow groove is scarcely perceptible, the face being practically transverse and smooth.

Formation and Locality.—Middle Cambrian: (C2) Lower shale member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 40 (part of the third list of fossils), and fig. 10 (beds 4 and 5), p. 38], 2 miles (3.2 km.) south of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Collected by Eliot Backwelder.

Orthotheca daulis Walcott.

Plate 5, Figure 24.

Orthotheca daulis WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 20. (Described and discussed as a new species essentially as on page 96.)

Shell elongate, slender, tapering gradually to an acute point. Transverse section subcircular, slightly flattened on the dorsal side. Ventral face strongly and regularly convex transversely; the dorsal and ventral faces meet to form the rounded lateral angles of the shell, the dorsal face being narrow and slightly flattened. Aperture transverse, as indicated by the transverse lines of growth.

Surface of the shell smooth and polished, with only a few very obscure traces of transverse concentric lines of growth.

A specimen 13 mm. long has a diameter of 4 mm. at the larger and 1.75 mm. at the smaller end; on the side, 2 mm. and 1 mm.

This species resembles, in its slender tube and nearly circular section, *Hyolithes communis* Billings [Walcott, 1891*a*, plate 77, figs. 3, 3*a–g*]. It may be compared with *Orthotheca stylus* Holm [1893, p. 52, plate 1, figs. 16–20; plate 6, figs. 6–9], except that it does not have the curvature of that species nor the cancellated surface. Its slender tube and nearly circular section are much like those of *Orthotheca teretiusculus* Linnarsson as illustrated by Holm in his memoir on Hyolithidæ [1893, p. 51, plate 1, figs. 21–24].

Formation and Locality.—Middle Cambrian: (C23) Upper part of thin-bedded, gray oolitic limestone at the base of the Ch'ang-hia formation [Blackwelder, 1907*a*, p. 32 (second list of fossils), and fig. 6 (bed 20), p. 25], 50 feet (15 m.) below the base of the cliffs 1 mile (1.6 km.) east-southeast of Ch'ang-hia, Shan-tung, China.

Collected by Eliot Blackwelder.

Orthotheca delphus Walcott.

Plate 6, Figures 1, 1*a–b*, 5, 6.

Orthotheca delphus Walcott, 1905, Proc. U. S. Nat. Mus., vol. xxix, p. 20. (Described and discussed as a new species essentially as below.)

Shell straight, elongate, slender, tapering gradually to an acute point. Transverse section subelliptical, with the dorsal side flattened. Dorsal face gently convex, lateral angles rounded. Ventral face moderately convex. Aperture about transverse, as indicated by the concentric striæ and lines of growth. Shell of medium thickness.

Surface of the shell transversely or concentrically striated by somewhat irregular, raised, sharp, fine, closely arranged striæ; on the rounded central side a few slightly oblique, longitudinal, elevated lines occur near the larger end.

The largest specimen has a length of 9 mm., with a width of 1 mm. at the smaller end and 1.75 mm. at the larger end.

There is some variation in the transverse section of the shell, owing to difference in the convexity and flattening of the dorsal face. In some specimens, toward the apical end, the section is a rather narrow ellipse.

The elliptical section and the fine, raised, transverse striæ serve to distinguish this species from any other known to me.

Formation and Locality.—Middle Cambrian: (C57) Limestone nodules in the lower shale member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 40 (first list of fossils)], 3 miles (4.8 km.) south of Kao-kia-p'u, and 4 miles (6.4 km.) north of Sin-t'ai-hién, Sin-t'ai district, Shan-tung, and (C4) limestone nodules at the base of the lower shale member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 40 (second list of fossils), and fig. 10 (bed 4), p. 38], 3 miles (4.8 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Collected by Eliot Blackwelder.

This species is very abundant in the *Dorypyge richthofeni* zone of Manchuria: Middle Cambrian, (35n and 35r) Fu-chóu series; limestones near the base of the

series just above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general section giving stratigraphic relations], collected in a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria, China.

Collected by J. P. Iddings and Li San.

In the argillaceous shales (36g) above the limestones of 35n and 35r, a few specimens were collected of a slender, flattened *Orthotheca* that is probably *O. delphus*. This form I refer to as *Orthotheca* cf. *delphus*, as the material is too poorly preserved for an accurate determination of its specific relations.

Orthotheca doris Walcott.

Plate 6, Figure 2.

Orthotheca doris WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 21. (Described and discussed as a new species essentially as below.)

Shell elongate, slender, and regularly tapering. Transverse section oval or circular; in the type and only specimen the shell is somewhat crushed, which leaves the original form in doubt. The dorsal face appears to have been moderately convex, with rounded lateral angles that pass into the convex, rounded ventral side. Transverse striæ and lines of growth indicate that the aperture was probably transverse. Shell apparently strong.

Surface of shell transversely or concentrically marked by lines of growth, with more or less irregular striæ between them; in addition there is a finely pitted surface between the striæ, and sometimes on them, that gives a very peculiar aspect to the surface under a strong lens.

The fragment representing this species has a length of 7.5 mm., with a transverse diameter at the larger end of 5 mm.

This species is characterized by the peculiar, irregularly pitted surface.

Formation and Locality.—Middle Cambrian: (C32) A fine-grained bluish-black limestone bowlder believed to have come from the lower part of the Ki-sin-ling limestone [Blackwelder, 1907*c*, p. 272], collected in river drift 1 mile (1.6 km.) south of Chön-p'ing-hién, on the Nan-kiang River, southern Shen-si, China.

Collected by Bailey Willis and Eliot Blackwelder.

Orthotheca glabra Walcott.

Plate 5, Figures 23, 23*a*; Plate 6, Figure 7.

Orthotheca glabra WALCOTT, 1911, Smithsonian Misc. Coll., vol. 57, No. 4, pp. 75–76, figs. 5 and 5*a*. (Described and discussed as a new species essentially as below.)

Form an elongate, slender, rounded tube, with the dorsal face less convex than the sides and ventral face. Transverse section round, except for the slightly flattened dorsal side. Operculum unknown. Shell rather thick, and with a smooth surface.

The largest specimen in the collection has a length of 5 mm.

This species is distinguished from other Chinese forms by its rounded tube and smooth surface. It is the representative in form of the American *Orthotheca communis* Billings.[1]

Orthotheca glabra occurs abundantly in association with *Hyolithes cybele* Walcott, in the *Dorypyge richthofeni* zone of Manchuria. Some of the shells have a long, slender, terminal section to the tube that is more or less slightly curved. It

[1]Tenth Ann. Rept. U. S. Geol. Survey, 1890, plate 77, figs. 3, 3*a–g*.

is so slender and round that it suggests the tube of *Hyolithellus* [Walcott, 1891*a*, plate 79, fig. 1*a*, Tenth Ann. Rept. U. S. Geol. Survey].

Formation and Locality.—Middle Cambrian: (C71) Massive cliff-making limestone in the central portion of the Ki-chóu formation [Willis and Blackwelder, 1907, pp. 139 and 145 (second list of fossils)], 4 miles (6.4 km.) southwest of Tung-yü; and (C72), thin green-gray limestone interbedded with ocherous and green clay shales, overlying the massive oolite in the Ki-chóu formation [idem, pp. 139 and 145 (third list of fossils)], 4 miles (6.4 km.) east of Fang-lan-chön; both in Shan-si, China.

Collected by Eliot Blackwelder.

Also (35n), Middle Cambrian: Fu-chóu series; limestones near the base of the series just above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general section giving stratigraphic relations], collected in a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria, China.

Collected by J. P. Iddings and Li San.

Orthotheca sp. undt. Walcott.

Plate 6, Figure 3.

Orthotheca sp. undt. Walcott, 1905, Proc. U. S. Nat. Mus., vol. xxix, p. 21. (Characterized as below.)

Fragments of a small, elongate, slender *Orthotheca* occur in the Upper Cambrian. The species has a transverse section much like that of *O. daulis* [p. 94] except that the dorsal face is much broader, which gives a rounded, subtriangular outline to the section, resembling in this respect *O. cyrene* [p. 93], but the latter has a shallow groove on the dorsal face which is absent in the fragments under consideration.

Formation and Locality.—Upper Cambrian: (C56) Lower part of Ch'au-mitién limestone, 25 feet (7.5 m.) below the top of Pagoda Hill [Blackwelder, 1907*a*, p. 42 (part of last list of fossils)], 1 mile (1.6 km.) west of Tsi-nan, Shan-tung, China.

Collected by Eliot Blackwelder and Li San.

CEPHALOPODA.

Genus CYRTOCERAS Goldfuss.

Cyrtoceras cambria Walcott.

Plate 6, Figures 4, 4*a–c*.

Cyrtoceras cambria Walcott, 1905, Proc. U. S. Nat. Mus., vol. xxix, p. 22. (Described and discussed as a new species essentially as below.)

Shell gently curved, laterally compressed. Section ovate, dorso-ventral diameter as compared with the lateral diameter toward the last chamber being nearly as 4 to 3, the greatest lateral diameter being nearer the dorsal than the ventral side; dorsal side more obtusely rounded than the ventral. Septa arching slightly forward from the dorsal side; short, about five in a distance of 2.5 mm. where the shell has a diameter of from 1 to 1.5 mm. Chamber of habitation supposed to be of moderate depth; none of the specimens clearly shows the margin of the aperture.

This species is represented by a number of more or less fragmentary specimens. The largest has a dorso-ventral diameter near the aperture of 3 mm., with a length of 7 mm. to where the diameter is 1.25 mm.; the chamber of habitation appears to have a depth of 2 mm. The siphuncle in a specimen 2.25 mm. in the dorso-ventral diameter has a diameter of less than 0.2 mm.; it is situated on the dorsal side and almost reaches the exterior surface of the thin shell, which is somewhat thickened on the dorsal side.

This little shell appears to be a true *Cyrtoceras*. Occurring, as it does, well down toward the base of the Ch'au-mi-tién limestone, the fauna of which is of Upper Cambrian age, makes it of great interest, as it is the oldest known representative of the genus; and unless *Volborthella* is considered to be a cephalod, it is the oldest known representative of that class.

Formation and Locality.—Upper Cambrian: (C56) Lower part of Ch'au-mi-tién limestone, 25 feet (7.5 m.) below the top of Pagoda Hill [Blackwelder, 1907*a*, p. 42 (part of last list of fossils)], 1 mile (1.6 km.) west of Tsi-nan, Shan-tung, China.

Collected by Eliot Blackwelder and Li San.

TRILOBITA.

Genus AGNOSTUS Brongniart.

Agnostus chinensis Dames.

Plate 7, Figures 4–6, 6*a*.

Agnostus chinensis DAMES, 1883, China, Richthofen, vol. IV, p. 27, plate 2, figs. 18, 19. (Species described and discussed.)

This species is described in detail by Doctor Dames. He compares it with *Agnostus canadensis* Billings [1860, p. 304], *A. cyclopyge* Tullberg [1880, p. 26], from Sweden, *A. communis* and *A. neon* Hall and Whitfield [1877, pp. 228, 229], from Nevada, and *A. josepha* Hall [1863, p. 178], from Wisconsin, pointing out that this species from China belongs to the group *Longifrontes* of Tullberg [1880, p. 13]. Twenty years later Doctor Monke, when studying a species of *Agnostus* from Shantung, referred to the form of the pygidium of Doctor Dames's species, calling attention to its narrowing anteriorly, and the presence of two transverse furrows on the anterior portion of the axial lobe. Doctor Monke recognized the close resemblance in the cephalic shield of the two forms, but on account of the differences in the associated pygidia, described the species in his material as *A. koerferi* [1903, p. 111]. With a large number of fine specimens of the cephalon of the latter species for comparison I find that the range of variation in form from the same locality includes both *A. chinensis* and *A. koerferi*, but I do not find any pygidium similar to that illustrated by Doctor Dames and on that account think that the *A. koerferi* should be retained, although in my first review of Doctor Monke's species I placed it under *A. chinensis* [Walcott, 1906, p. 564]. Some specimens have indications of two transverse furrows on the side of the axial lobe opposite the central tubercle, but none of them show furrows crossing the axial lobe.

The cephalon and pygidium represented by figures 6 and 6*a*, copied from Dames, have evidently been somewhat compressed and flattened in the shaly limestone. The compression of the frontal space of the cephalon has increased the sharpness of the longitudinal furrow, a feature that is occasionally seen on specimens in our collection, and the median lobe of the pygidium has been broadened and a longitudinal crack made both in the lobe and the transverse ring in front of it. The specimens illustrated by figures 5, 5*a–c*, are convex and preserve their natural form, and are identical with fine specimens recently received from southeast of Mukden.

In the J. P. Iddings collection from Manchuria there is a fine series of specimens representing this species both in limestone and argillaceous shale. It appears to have a vertical range of about 200 feet (60 m.) above the basal sandstone of the section. Some of the compressed pygidia in the shale are similar in appearance to the pygidium illustrated by Dames, and which is copied in this paper on plate 4, figure 6*a*.

Formation and Locality.—Middle Cambrian: (C1 and C2) Lower shale member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 40 (part of the third list of fossils), and fig. 10 (beds 4 and 5), p. 38], 2 miles (3.2 km.) south of Yen-chuang, Sin-t'ai district, Shan-tung, and (C57) in limestone nodules in the lower shale member of the Kiu-lung group [idem (first list of fossils)], and 3 miles (4.8 km.) south of Kao-kia-p'u, and 4 miles (6.4 km.) north of Sin-t'ai-hién, Sin-t'ai district, Shan-tung; also (C71), massive cliff-making limestone in the central portion of the Ki-chóu formation [Willis and Blackwelder, 1907, pp. 139 and 145 (second list of fossils)], 4 miles (6.4 km.) southwest of Tung-yü, Shan-si, China.

Collected by Bailey Willis and Eliot Blackwelder.

The specimens described by Doctor Dames occur in a dense gray limestone, Province of Liau-tung, southeast of Mukden, Sai-ma-ki, Manchuria, China.

Specimens have also been collected by J. P. Iddings and Li San from the following localities: (35n and 35r) Fu-chóu series; limestones near the base of the series just above the white quartzite, and (36e) shales interbedded with limestones near the base of the series just above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general section giving stratigraphic relations], all three collected in a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung; also (35p), shales about 80 feet (24.m) above the white quartzite, and (36h) shales about 130 feet (40 m.) above the white quartzite [see idem], collected in a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, and (35o and 36g) shales about 130 feet (40 m.) above the white quartzite [see idem], collected in drainage cuts a short distance back from the bluff (see 35n) forming the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria, China.

Agnostus douvillei Bergeron.

Plate 7, Figures 3, 3*a*–*b*, 8, 8*a*; Plate 11, Figures 6, 7.

Agnostus douvillei BERGERON, 1889, Bull. Soc. Geol., France, 3d ser., vol. XXVII, p. 43, plate 12, fig. 3. (Species described and illustrated.)

Agnostus koerferi MONKE, 1903, Jahrb. Königl. Preuss. Geol. Land. und Bergakad., vol. XXIII, Haft 1, p. 111, plate 3, figs. 1–9. (Described and discussed as a new species.)

Doctor Monke illustrates this species very fully. A comparison of the photographs of the slabs of limestone on which *A. koerferi* Monke and *A. douvillei* Bergeron occur indicates that the two are identical, although *A. douvillei* is represented by a broken cephalon. A second cephalon occurs on the slab illustrated by J. Bergeron that is clearly the form described as *A. koerferi* by Monke.

Doctor Monke's specimens are on slabs of limestone found at Yen-tsy-yai, province of Shan-tung, China. He refers the associated fauna to the Upper Cambrian, but the detailed work of Eliot Blackwelder [1907*a*, p. 41] shows it to belong to the Middle Cambrian, just below the Ch'au-mi-tién limestone.

In Manchuria Dr. J. P. Iddings found this species both in argillaceous shale and on the surface of thin layers of limestone of the *Drepanura premesnili* fauna.

Formation and Locality.—Middle Cambrian: (C6) Thin platy limestone in the upper shale member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 41 (second list of fossils), and fig. 10 (bed 12), p. 38], 2.5 miles (4 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung, and (C55) just below the Ch'au-mi-tién limestone in the Ku-shan shales [idem, p. 43], in isolated hills at an elevation of 380 feet (114 m). above the Wön-ho, 12 miles (19 km.) south 80° east of Tsi-nan, Shantung, China.

Collected by Bailey Willis and Eliot Blackwelder.

Also (36f), Fu-chóu series; about 1,000 feet (305 m.) above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general stratigraphic relations]; collected in a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria, China.

Collected by J. P. Iddings and Li San.

Agnostus kushanensis Walcott.

Plate 7, Figures 7, 7*a–b*.

Agnostus kushanensis Walcott, 1905, Proc. U. S. Nat. Mus., vol. xxix, p. 22. (Described and discussed as a new species essentially as below.)

Cephalic shield moderately convex, a little wider than long, semicircular in outline, and slightly contracted at the postero-lateral angles; the narrow, rim-like, rounded border is broadest at the front, narrowing toward the postero-lateral angle, around which it curves, and extends about one-fourth the distance across the posterior margin of the cephalon; dorsal furrow well defined on the sides but rather faint in front of the large posterior lobe of the glabella.

The glabella is formed of a posterior, slightly convex lobe, that is little more than one-fourth the width of the cephalon and less than one-half its length; it is marked a little in advance of its center by a small, pointed tubercle; in front of the posterior lobe there is a faintly outlined, conical extension of the glabella that differs more or less in form and strength in nearly every specimen of the cephalon; it is usually very obscure; lateral lobes moderately convex and uniting in front without interruption in the convexity of the surface.

The thoracic segments associated with the cephalic and caudal shields have a convex axial lobe with narrow pleural lobes; the axial lobe is divided into a central portion and two lateral portions by narrow furrows, giving the effect of two large, oval tubercles between the dorsal furrow and the central portion of the segment; the short pleural lobe is marked by a very narrow pleural furrow a short distance back of its center.

The caudal shield associated with the cephalic shield is slightly shorter in proportion to its width and less convex; it is bordered by a flat, rather broad rim, that is narrow at the front margin, gradually increasing to its greatest width behind, where its inner margin curves inward to form a blunt angle at the point opposite the axial lobe; the front margin is narrow and elevated in front of the lateral lobes, and bordered with a narrow, slightly convex, sharply defined axial segment.

Axial lobe about one-third the entire width, moderately convex, and marked on its anterior third by an elongate, slightly elevated tubercle from which, on some specimens but not on others, two very faint grooves extend outward and then curve obliquely backward to the dorsal furrow, the front groove being opposite the apex of the tubercle; in some examples the axial lobe contracts opposite the central tubercle and expands at the frontal margin, where an oblique, very faintly defined furrow outlines a small, oval lobe; dorsal furrow narrow and sharply defined all about the central axis; back of the axis it unites and passes back into the furrow within the border; lateral lobes gently convex, usually about the width of the axial lobe near the central portions, narrowing posteriorly, and dying out at the short, shallow furrow at the posterior point of the axial lobe.

Surface of cephalic and caudal shields and thoracic segments minutely punctate.

This species differs from *Agnostus chinensis* Dames [1883, p. 27, plate 2, figs. 18, 19], which occurs abundantly in the Ch'ang-hia formation, in having a short glabella and broader lateral lobes on the cephalic shield, and broader lateral lobes

and flat border on the pygidium. It is of the type of and very closely related to *A. parvifrons* Linnarsson [1869; see Tullberg, 1880, plate 2, figs. 27, 28], from which it differs in the proportion of the glabella to the length of the cephalic shield and in the flatter margins of the cephalic and caudal shields.

Formation and Locality.—Middle Cambrian: (C57) In limestone nodules in the lower shale member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 40 (first list of fossils)], 3 miles (4.8 km.) south of Kao-kia-p'u, and 4 miles (6.4 km.) north of Sin-t'ai-hién, Sin-t'ai district, Shan-tung, China.

Agnostus parvifrons latelimbatus Lorenz.

Plate 7, Figures 1, 1*a*.

Agnostus parvifrons latelimbatus LORENZ, 1906, Zeitschr. deutsch. geol. Gesellsch., vol. LVIII, pt. II, p. 84, plate 4, figs. 9, 9*a–b*; plate 5, figs. 10, 11. (Described and illustrated as a new variety.)

The original specimens of this variety of *Agnostus parvifrons* Linnarsson are unsatisfactory. The species is represented, but the characters for determining the variety are not clear, owing to the imperfect specimens.

Formation and Locality.—Middle Cambrian: Kiu-lung group, Wang-tschuang, Shan-tung, China.

Agnostus sp. undt.

One specimen of a pygidium of an *Agnostus* of the same general character as that of *A. douvillei* Bergeron [p. 100] occurs in limestones of the lower Ch'au-mi-tién formation. In the absence of the cephalon I will only call attention to the occurrence.

Formation and Locality.—Upper Cambrian: (C34) Purplish-gray limestone about 100 feet (30 m.) above the base of the Ch'au-mi-tién formation [Blackwelder, 1907*a*, p. 36 (part of first list of fossils)], in road at northeastern corner of small village near Ch'au-mi-tién, Shan-tung, China.

Collected by Eliot Blackwelder.

A species of *Agnostus* is indicated in the upper beds of the Ch'ang-hia formation by the presence of a single pygidium that differs from *A. chinensis* Dames [p. 99] in having a proportionately stronger and more rounded marginal rim. The median lobe is not so broad in its posterior half and not so convex.

Formation and Locality.—Middle Cambrian: (C24) Near top of black oolite group in the uppermost layers of the Ch'ang-hia formation [Blackwelder, 1907*a*, p. 33 (part of last list of fossils)], 2 miles (3.2 km.) east of Ch'ang-hia, Shan-tung, China.

Collected by Eliot Blackwelder.

Genus MICRODISCUS Emmons.

Microdiscus Emmons, WALCOTT, 1886, Bull. U. S. Geol. Survey, No. 30, p. 152.

Microdiscus orientalis Walcott.

Plate 7, Figure 10.

Microdiscus orientalis WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 24. (Described and discussed as a new species essentially as below.)

There is in the collection but a single specimen of the matrix of a portion of the cephalon of this species. This indicates the cephalon to have been semicircular in outline, with a strong, rounded, frontal border, marked by ten or more transverse furrows, very much in the same manner as *M. connexus* Walcott [1887, p. 194, plate 1, figs. 4, 4*b*]. In front of the border there is a very narrow, slightly elevated rim.

Cheeks convex and sloping from the center toward the narrow, sharp dorsal furrow about the glabella and to the furrow within the border of the cephalon. A very narrow ridge extends just back of the antero-lateral angles of the glabella outward so as to disappear in the furrow within the outer border.

Glabella very narrow in front, gradually widening toward the base, and, from the slight indication in the specimen, continued backward in an occipital spine; it is marked by two transverse lightly impressed furrows, and what may be a faintly impressed occipital furrow.

This species shows characters that occur in two described forms: the border of the head and the occipital spine are much like those of *M. connexus* Walcott; the transverse furrows of the glabella recall those of some specimens of *M. speciosus* Ford [1873, p. 137, figs. 2*a*–*b*]. Its occurrence in the Cambrian rocks of China is most interesting.

Formation and Locality.—Middle Cambrian: (C32) A fine-grained bluish-black limestone bowlder believed to have come from the lower part of the Ki-sin-ling limestone [Blackwelder, 1907*c*, p. 272]; collected in river drift 1 mile (1.6 km.) south of Chön-p'ing-hién, on the Nan-kiang River, southern Shen-si, China.

Collected by Bailey Willis and Eliot Blackwelder.

Genus REDLICHIA Cossmann.

Hoeferia Redlich, 1901, Mem. Geol. Survey India, new. ser., vol. 1, p. 2. (Genus characterized and discussed.)

Not *Hoeferia* Bittner, 1895.

Redlichia Cossmann, 1902, Revue Critique Paléozoologie, Sixiéme Ann., p. 52. (Replaces *Hoeferia* Redlich by *Redlichia*.)

Redlichia Walcott, 1905, Proc. U.S. Nat. Mus., vol. xxix, p. 24. (Genus described and discussed as below.)

Original description (by Doctor Redlich).—"The cephalic shield is almost semicircular, slightly elevated, possesses movable cheeks and two long cheek spines. The glabella is cylindrical, slightly contracted toward the middle, provided on each side with four lateral furrows. The palpebral lobes, which surround the glabella in one continuous curve, are completely separate from it and not confluent as in *Olenellus*. The facial sutures are well developed in all the specimens, and, in consequence of this, free cheeks are present.

"The suture begins in the first quarter of the external margin (reckoned from the glabella), extends along the eyes, and toward the posterior margin is again directed outward. The fixed cheeks are very narrow, whilst the free cheeks, which are provided with long cheek-spines, are almost double the width.

"Of the thorax only isolated segments are preserved. The axial part is elevated; the pleuræ are grooved ('*plèvres a sillon*' of Barrande), and end in a backwardly directed spine.

"On the glabella the surface of the test shows fine backwardly directed ridges which are, however, so fine that they are visible only under the lens. On the thickened margin they are also present, but so much stronger that they can easily be shown in the figure. The cheeks, even when highly magnified, show nothing of the sort, but at most a fine punctation, which, however, is mainly due to the structure of the test."

Genotype.—Redlichia noetlingi Redlich [1901, p. 3, plate 1].

Doctor Redlich compares this form with the genera *Protolenus, Paradoxides,* and *Metadoxides,* but does not note its close resemblance to *Zacanthoides* of the Middle Cambrian fauna of Nevada. For the purpose of comparison, figures of the genera *Redlichia, Zacanthoides,* and *Protolenus* are illustrated on plate 24.

In India the type species *Redlichia noetlingi* [Redlich, 1901, p. 3] occurs near the summit of the Cambrian series of formations. In China *R. nobilis* [p. 105] occurs near the base of the Man-t'o formation, not far above the Archean complex. *Redlichia chinensis* is found in the central portions of the Man-t'o formations.

In my first preliminary paper on the Cambrian faunas of China[1] I stated that:

In China *R. nobilis* occurs near the base of the ManTo formation, not far above the Archean complex. *R. chinensis* is found in the central portions of the ManTo formations, and *R. finalis* occurs nearly 1,000 feet or more higher in the section near the top of the Chang Hsia formation. This distribution indicates that *Redlichia* is a Middle Cambrian genus; also that it may be in the upper portion of the Lower Cambrian, but with our present information this is somewhat doubtful, as the fauna of the ManTo formation is not directly Lower Cambrian.

Recently Dr. H. Mansuy, a geologist of Indo-China, has discovered some entire specimens of *Redlichia chinensis* near Yunnan-Fu, in Yunnan, associated with undescribed trilobites that have a strong Lower Cambrian facies. This discovery, taken in connection with the occurrence of the brachiopod genus *Obolella*, and a gastropod genus *Stenotheca* represented by the species *rugosa*, leads me to conclude that the *Redlichia chinensis* fauna is of late Lower Cambrian age, as given in the table showing the association of genera and species in the Man-t'o formation [Walcott, 1905*b*, p. 6].

It is quite probable, from the character shown by the entire specimens of M. Mansuy, that the specimens described as *Redlichia finalis* Walcott [idem, p. 26] may belong to another genus. It differs from the typical forms of the genus *R. noetlingi* and *R. chinensis* in having a strong nuchal spine, less tapering glabella, and broader lobes between the eye and the glabella.

I wish to call attention to the resemblance between the forms that have been referred to *Olenellus* in Australia[2] by A. H. Foord and *Redlichia*. As far as can be determined by the illustrations and a study of the specimens of the cephalon illustrated by R. Etheridge, Jr.,[3] there seems to be no escape from the conclusion that the Australian form should be referred to the genus *Redlichia*.

Redlichia chinensis Walcott.

Plate 7, Figures 11, 11*a–d;* Plate 24, Figures 1, 1*a*.

Redlichia chinensis WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 25. (Discussed as a new species essentially as below.)

This species differs from *Redlichia noetlingi* Redlich [1901, p. 3], the type of the genus from India, in its more conical glabella and smaller anterior lobe of the glabella; otherwise the two forms are very much alike, as far as can be determined by the present means of comparison. From *Redlichia nobilis* [p. 105] it differs in having a proportionately less cylindrical glabella and much larger anterior fixed cheeks.

The stratigraphic range of the species is from the lower to the central portions of the Man-t'o formation.

Formation and Locality.—Lower Cambrian: (C15 and C16) Slaty black limestone in the lower part of the Man-t'o shale [Blackwelder, 1907*a*, p. 26, third paragraph; and fig. 6 (bed 7), p. 25], (C15) at Ch'ang-hia, and (C16) 2 miles (3.2 km.)

[1]Proceedings U. S. Nat. Mus., vol. 29, 1905, p. 25.

[2]Geological Magazine, London, Decade 3, vol. 7, 1890, p. 99, plate 4, figs. 2, 2*a–b*.

[3]Transactions Royal Society of South Australia, vol. 29, 1905, p. 247, plate 25, fig. 1.

south of Ch'ang-hia; also (C27), buff and drab shales in the lower part of the Man-t'o shale [Blackwelder, 1907*a*, p. 26, third paragraph; and fig. 6 (bed 7), p. 25], on crest of ridge at Ch'ang-hia, Shan-tung, China.

Collected by Eliot Blackwelder.

Dr. H. Mansuy reports this species from southern China, near Yunnan-Fu, province of Yunnan.

Redlichia ? finalis Walcott.

Plate 7, Figures 13, 13*a–b*.

Redlichia finalis WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 26. (Discussed as a new species essentially as below.)

This species is represented by one imperfect cephalon, several free cheeks, and several long spines similar to those occurring with *R. chinensis* [p. 104], which were probably attached to a segment of the thorax as in *Zacanthoides typicalis* (Walcott) [1886, plate 25, fig. 2]. The fragment of the cephalon indicates an almost cylindrical glabella and elongate eye-lobe; the free cheek indicates a shorter anterior fixed cheek than that of *R. nobilis*. The material representing this species is imperfect, but the fact that it occurs near the top of the Ch'ang-hia limestone, 1,000 or more feet above *R. chinensis* and *R. nobilis*, in a strongly marked Middle Cambrian fauna, makes it desirable to give the form a specific name. It appears to be nearer the type of the genus *R. noetlingi* Redlich [1901, p. 3] from India than the other two species from China.

Formation and Locality.—Middle Cambrian: (C58) Green shale near the middle of the Ch'ang-hia limestone, at top of hill 2 miles (3.2 km.) south-southeast of Kao-kia-p'u, Shan-tung, China.

Collected by Eliot Blackwelder.

Redlichia nobilis Walcott.

Plate 7, Figures 12, 12*a–e*.

Redlichia nobilis WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 26. (Discussed as a new species essentially as below.)

This species is closely related to *Redlichia noetlingi* Redlich [1901, p. 3]; it differs in the form of the posterior segment of the glabella and the somewhat less cylindrical form of the glabella.

From *Redlichia chinensis* [p. 104] it differs in its less tapering glabella and shorter anterior fixed cheeks.

As far as known, it occurs only in the lower portion of the Man-t'o formation.

Formation and Locality.—Lower Cambrian: (C3) Lower part of the Man-t'o shale formation [Blackwelder, 1907*a*, p. 28 (list of fossils at bottom of page), and fig. 8*a* (bed 20), p. 28], on the southeast slope of Hu-lu-shan, 2.5 miles (4 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Collected by Eliot Blackwelder.

Redlichia sp. undt. (*a*) Walcott.

Plate 7, Figure 14.

Redlichia sp. undt. WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 26. (Species discussed as below.)

A large free cheek and two thoracic spines, much like those found with *R. chinensis* [p. 104], are all that is known of this species. The angle of divergence of the lateral spine is much greater than in other species, and the stratigraphic horizon is higher in the section.

Formation and Locality.—Middle Cambrian: (C6) Thin, platy limestone in the upper shale member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 41 (second list of fossils), and fig. 10 (bed 12), p. 38], 2.5 miles (4 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Collected by Eliot Blackwelder.

Redlichia sp. undt. (*b*).

Plate 7, Figure 15.

This species is represented by a peculiar free cheek associated with fragments of *Redlichia chinensis* [p. 104]. It differs from the free cheeks referred to the latter species in having a less pronounced angle between the facial suture and in the genal spine, and in the presence of a sharp spine at the angle formed by the union of the base of the eye-lobe and the facial suture outlining the postero-lateral limb.

Formation and Locality.—Lower Cambrian: (C16) Slaty black limestone in the lower part of the Man-t'o shale [Blackwelder, 1907*a*, p. 26, third paragraph, and fig. 6 (bed 7), p. 25], 2 miles (3.2 km.) south of Ch'ang-hia, Shan-tung, China.

Collected by Eliot Blackwelder.

Redlichia sp. undt. (*c*).

Plate 7, Figures 16, 16*a*.

Only one free cheek is known of this form. It is not unlike the free cheek of *Redlichia chinensis* [p. 104] in outline, but it differs in its strongly tubercular surface slightly defined marginal rim, and narrower body. The associated fragment of the axis of a thoracic segment bearing a strong spine has tubercles on the segment and the base of the spine.

Formation and Locality.—Lower Cambrian: (C27) Buff and drab shales in the lower part of the Man-t'o shale [Blackwelder, 1907*a*, p. 26, third paragraph; and fig. 6 (bed 7), p. 25], on crest of ridge at Ch'ang-hia, Shan-tung, China.

Collected by Eliot Blackwelder.

Genus ALBERTELLA Walcott.

Albertella Walcott, 1908, Smithsonian Misc. Coll., vol. 53, No. 2, p. 18.

Albertella pacifica Walcott.

Plate 12, Figure 3.

Albertella pacifica Walcott, 1911, Smithsonian Misc. Coll., vol. 57, No. 4, pp. 76–77, plate 14, fig. 6.
(Described and discussed as a new species essentially as below.)

Of this form only one fragment of the pygidium was found in the collection from Manchuria. This is so characteristic that I do not hesitate to identify it as the pygidium of an *Albertella*, although stratigraphically it occurs at a higher horizon in the Middle Cambrian than the American species of the genus. For the purpose of comparison figures of *Albertella helena* Walcott and *A. bosworthi* Walcott are inserted on the same plate with *A. pacifica*.

A pygidum illustrated by M. Barrande [1852, plate 12, fig. 15] as *Paradoxides desideratus* Barrande may possibly belong to a species of *Albertella*. The axial lobe of the pygidium has seven rings and a terminal section and the pleural lobes have lateral spines.

Formation and Locality.—Middle Cambrian: (36f) Fu-chóu series; about 1,000 feet (305 m.) above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general stratigraphic relations]; collected in a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria, China.

Collected by J. P. Iddings and Li San.

Genus DORYPYGE Dames.

Dorypyge DAMES, 1883, China, Richthofen, vol. IV, p. 23. (Description and discussion of the genus.)
Dorypyge ZITTEL, 1885, Handbuch der Pal., vol. II, Munich, p. 596. (Gives brief outline of genus.)
Dorypyge WALCOTT, 1886, Bull. U. S. Geol. Survey No. 30, p. 221. (Considers that *Dorypyge* may be synonymous with *Olenoides*.)
Dorypyge WALCOTT, 1889, Proc. U. S. Nat. Mus., vol. XI, p. 443. (Expresses opinion that *Dorypyge* and *Olenoides* are congeneric.)
Dorypyge MATTHEW, 1897, Trans. Roy. Soc. Canada, 2d ser., vol. III, sec. 4, p. 186. (Discusses genus and its relations to *Olenoides*.)
Dorypyge VON TOLL, 1899, Mém. de l'Acad. Imp. des Sciences de St. Pétersbourg, 8th ser., vol. VIII, No. 10, p. 35. (Discusses reference of species to *Dorypyge* and *Olenoides*.)
Dorypyge GRÖNWALL, 1902, Danmarks geol. Unders., 2d ser., No. 13, p. 126. (Discusses the genus at length and accepts Matthew's interpretation of it.)

Original description.—"Cephalic shield arched, with narrow, upturned frontal border. Facial sutures somewhat converging in front of the eyes, but widely separated at the anterior rim, and diverging behind the eyes toward the posterior border. Glabella high-arched, with three pairs of horizontal furrows but slightly developed. The neck-ring is widened cushion-like behind and runs out into a spine which is directed obliquely upward.

"Pygidium large; axis high-arched and sharply set off all around; axis and lateral parts divided into few but clearly defined segments; margin running out into a number of spines equal to the number of segments. Surface of cephalic and tail shields ornamented with fine warts." [Dames, 1883, p. 23.]

Doctor Dames compared the genus with *Peltura* and *Parabolina* on account of the course of the facial sutures and the presence of a spinose pygidium, and on this account placed the genus in the Olenid family. He states under the description of the type species, *D. richthofeni* Dames, that large numbers of the cephala and pygidia occurred in the collection, but none of the thoracic segments. In the material collected by Mr. Blackwelder fragments of the thoracic segments occur, and these show that the pleural groove is straight [see plate 8, fig. 1*d*], as in *Olenoides*, and not oblique, as in the Olenidæ and Paradoxidæ.

The differences between *Olenoides* and *Dorypyge* are:

(*a*) The glabella of *Olenoides* expands toward the front, while that of *Dorypyge* contracts in front of the pits in the dorsal furrow.

(*b*) The pleural lobes of the pygidium of *Olenoides* have broad, shallow furrows with sharp, narrow ridges separating them, while those of *Dorypyge* have narrow furrows with broad, rounded ridges between them. The type of *Olenoides*, *O. nevadensis*, has a finely granulated surface, and the type of *Dorypyge* a coarsely granulated surface. Species with a nearly smooth surface occur in both genera, *e. g.*, *Olenoides curticei* Walcott [1890, plate 94, fig. 1], *Dorypyge richthofeni lævis* Walcott.

Genotype.—*Dorypyge richthofeni* Dames [1883, p. 24].

To the type species there have since been added from Asia: *Dorypyge slatkowskii* Schmidt, *Dorypyge bispinosa* Walcott, and *Dorypyge richthofeni lævis* Walcott.

Dorypyge bispinosa Walcott.

Plate 8, Figure 3.

Dorypyge bispinosa WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 28. (Described and discussed as a new species essentially as below.)

This species is based on a pygidium having a strong, broad axis, narrow pleural lobes, and two long, strong spines that project obliquely backward from the postero-

lateral angle of the pygidium. The central axis has a length of 10 mm., with a width at the anterior end of 6 mm., and at the posterior terminal lobe of 6 mm., narrowing slightly at the second and third rings; it is divided by three shallow, rounded, transverse furrows into three slightly convex rings and a terminal ring nearly as long as the two posterior rings; there is also a narrow anterior ring that connected the pygidium with the thorax; the terminal ring is convex and slightly overhangs the margin; a node or slight swelling is indicated on each side of the median line where the ring slopes abruptly down to the margin. Dorsal furrow rounded and somewhat irregular.

Pleural lobes slightly narrower than the axis and arching from the dorsal furrow directly down to the border; the lobes are divided by three broad furrows into an anterior, marginal, elevated rim and two slightly concave segments; a third and posterior segment is indistinctly outlined; the furrows and segments terminate within a slightly thickened border. Three pairs of short spines occur on the border opposite the two anterior segments and frontal rim of the pleural lobe; opposite the faintly defined posterior segment there is a long, strong spine, and from the space between the latter spine and where the dorsal furrow intersects the border there is another longer and stronger spine that extends obliquely outward and backward.

The surface is marked by a few pustules that occur on the elevated portions of the rings of the axis and the pleural lobes; under a strong lens the crust appears to be slightly roughened and apparently minutely punctate.

Length of pygidium, 11 mm.; width at the anterior border, 16 mm.; width of axis, 6 mm.; width of pleural lobe at anterior portion, 5 mm.

In general outline this pygidium is somewhat like that of *Dorypyge richthofeni* Dames. It differs in the proportionately broader axis, narrower pleural lobes, and the pair of strong spines at the postero-lateral angle.

The pygidium of *Dorypyge danica* Grönwall [1902, plate 3, fig. 12] has two large, long posterior spines on each side next to the axis, also three short spines anterior to the long spines, as in *D. bispinosa*. The two species are quite unlike in their other characters.

Formation and Locality.—Middle Cambrian: (C2) Lower shale member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 40 (part of the third list of fossils), and fig. 10 (beds 4 and 5), p. 38], 2 miles (3.2 km.) south of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Collected by Eliot Blackwelder.

Dorypyge richthofeni Dames.

Plate 8, Figures 1, 1*a–f*.

Dorypyge richthofeni Dames, 1883, China, Richthofen, vol. IV, p. 24, plate 1, figs. 1–6. (Species described and discussed.)

Doctor Dames gives a detailed description of this species. The new material in the Carnegie Institution of Washington collection shows that the pleural lobes of the thoracic segments have a rounded, straight groove as in *Olenoides;* also that a spine occurs at the center of the axial lobe, as in *Olenoides*.

The specimens described by Doctor Dames were from Ta-ling and Wu-lo-pu.

In Manchuria the stratigraphic range of this species as now known is confined to the shales and interbedded limestones just above the white quartzite sandstone at the base of the section.

Formation and Locality.—Middle Cambrian: (C19) Uppermost layers of the Ch'ang-hia limestone [Blackwelder, 1907*a*, p. 33 (part of last list of fossils), at

Ch'ang-hia, (C29) near the top of the cliffy limestone in the Ch'ang-hia limestone [Blackwelder, 1907*a*, p. 32 (part of last list of fossils)], 1 mile (1.6 km.) west of Ch'ang-hia, (C30) layer in black oolite of the Ch'ang-hia limestone [idem, p. 33 (part of first list of fossils)], 25 feet (7.5 m.) above the second cliff at an elevation of 1,700 feet (568.9 m.) on top of the long north-and-south ridge at Ch'ang-hia, and (C24) near top of black oolite group in the uppermost layers of the Ch'ang-hia formation [idem (part of last list of fossils)], 2 miles (3.2 km.) east of Ch'ang-hia, Shan-tung, China; also (C1 and C2), lower shale member of the Kiu-lung group [idem, pp. 37 and 40 (part of the third list of fossils), and fig. 10 (beds 4 and 5), p. 38], 2 miles (3.2 km) south of Yen-chuang, Sin-t'ai district, (C57) limestone nodules in the lower shale member of the Kiu-lung group [idem (first list of fossils)], 3 miles (4.8 km.) south of Kao-kia-p'u, and 4 miles (6.4 km.) north of Sin-t'ai-hién, Sin-t'ai district, Shan-tung, and (C71) massive cliff-making limestone in the central portion of the Ki-chóu formation [Willis and Blackwelder, 1907, pp. 139 and 145 (second list of fossils)], 4 miles (6.4 km.) southwest of Tung-yü, Shan-si, China.

Collected by Eliot Blackwelder, Bailey Willis, and Li San.

Also from the following: (35n and 35r) Fu-chóu series; limestones near the base of the series just above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general section giving stratigraphic relations], and (35p), shales about 80 feet (24 m.) above the white quartzite [see idem], all three collected in a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria, China.

Collected by J. P. Iddings and Li San.

Dorypyge richthofeni lævis Walcott.

Plate 8, Figures 2, 2*a*–*b*.

Dorypyge richthofeni lævis Walcott, 1906, Proc. U. S. Nat. Mus., vol. xxx, p. 573. (Variety characterized.)

This variety is characterized by a nearly smooth surface. An associated pygidium and cephala of *D. richthofeni* Dames have tubercles over most of the surface.

Formation and Locality.—Middle Cambrian: (C71) Massive cliff-making limestone in the central portion of the Ki-chóu formation [Willis and Blackwelder, 1907, pp. 139 and 145 (second list of fossils)], 4 miles (6.4 km.) southwest of Tung-yü, Shan-si, and (C72) thin green-gray limestone interbedded with ocherous and green clay shales, overlying the massive oolite in the Ki-chóu formation [idem (third list of fossils)], 4 miles (6.4 km.) east of Fang-lan-chön, Shan-si, China.

Collected by Eliot Blackwelder.

Genus TEINISTION Monke.

Teinistion Monke, 1903, Jahrb. königl. Preuss. Geol. Landesanstalt und Bergakademie, vol. xxiii, pt. 1, p. 117. (Genus described and discussed.)

Dorypygella Walcott, 1905, Proc. U. S. Nat. Mus., vol. xxix, p. 29. (Genus described and discussed as a new genus.)

Cephalon transversely semicircular, with a truncato-conical glabella, having a postero-lateral lobe in the dorsal furrow, and a narrow frontal rim and border; fixed cheeks medium to broad, with relatively large, elevated palpebral lobes; facial sutures, cutting the anterior rim in front of the anterior base of the eye-lobe, extend inward and backward in a slight outward curve to the eye-lobe; arching about the eye-lobe they extend outward and backward with a sigmoid flexure, cutting the posterior rim within the postero-lateral angle.

Associated pygidia transversely semicircular, axis conical, with two or more rings, marginal border spinose, with the anterior pair of spines, in the type species, very strong.

It may be that some of the pygidia described under *Olenoides* and *Damesella* belong to this genus, but with our present knowledge it would be difficult to identify them.

The genus is characterized by the peculiar glabella, narrow frontal margin, and spinose pygidium. It is assumed that the pygidia associated with the cephala belong to the genus, as there is no other associated form to which they could be referred except *Damesella blackwelderi* [p. 125], and from this the pygidium differs in its short, conical axis, and the character of the spinose border.

The pygidia referred to *Teinistion* by Doctor Monke are unlike those found associated with the cephala of *Teinistion typicalis* Walcott. They are much more closely related to the pygidia referred to *Stephanocare sinensis* Bergeron. It may be that the generic reference of the pygidium in each case is incorrect, as the cephala are associated with various forms of pygidia and no entire specimen of either species has been found.

Genotype.—Teinistion lansi Monke.

The species referred to the genus are *T. lansi* Monke, *T. sodeni* Monke, *T. alcon* (Walcott), and *T. typicalis* (Walcott).

Teinistion alcon (Walcott).

Plate 9, Figure 3.

Dorypygella alcon Walcott, 1905, Proc. U. S. Nat. Mus., vol. xxix, p. 33. (Described and discussed as a new species essentially as below.)

This species is represented by a single, somewhat imperfect specimen of the central portions of the cephalon. Glabella broadly truncato-conical, its width at the base and its length being the same; a pair of short, shallow posterior furrows occurs, which outlines a postero-lateral lobe that extends out into and crosses the dorsal furrows; a second pair of furrows is very slightly indicated a short distance in advance of the posterior pair; back of the postero-lateral lobe there is a deep, sharp, narrow furrow on the slope into the occipital furrow; occipital furrow slightly defined, shallow near the center, and deeper laterally; occipital ring unknown; dorsal furrow well defined at the sides in front of the postero-lateral lobe.

Fixed cheeks about as broad as the glabella; they rise rather rapidly from the dorsal furrow to a height slightly greater than that of the glabella, and slope gently backward to the posterior furrow, and rather abruptly downward in front of the palpebral ridges; palpebral ridges broad and rounded; they originate opposite the glabella, somewhat interrupt the dorsal furrow, and extend outward subparallel to the frontal margin of the cephalon to the palpebral lobes; palpebral lobes broken away, but from the configuration of the broken part of the fixed cheek they appear to have been nearly one-half the length of the cephalon and placed on the most elevated portion of the cheek; frontal rim narrow and nearly flat, transverse, and sloping upward from in front of the glabella and the fixed cheeks.

One of the peculiarities of this cephalon is the blending of the palpebral ridge and the downward slope of the fixed cheek, so that it appears to be a strong ridge just back of the frontal rim; another peculiarity is the interruption of the dorsal furrow by the palpebral ridges and the postero-lateral lobes of the glabella.

The inner surface of the crust is minutely punctate, as shown by the minute papillæ on the cast; this may indicate that the outer surface was finely granulose.

Length of the cephalon, exclusive of the occipital ring, of the type and only specimen, 6 mm., with a width near the edge of the palpebral lobes of 10 mm.

This species is distinguished from *T. typicalis* by its broader glabella and fixed cheeks, and upward sloping frontal rim, and from *T. lansi* Monke by the absence of a frontal limb and the character of the lobes of the glabella. The pygidia which are referred to *T. lansi* may possibly belong to *T. alcon*; but from the fact that they are evidently from a different bed of limestone, and that there are no specimens of the cephalon associated with the pygidia, I do not think it best to include them under this species, especially as the cephalon of *T. lansi* and the pygidia appear to be from the same bed of limestone.

Formation and Locality.—Middle Cambrian: (C 12) Gray limestone near the top of the middle limestone member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 41 (part of the first list), and fig. 10 (bed 7), p. 38], 3.25 miles (5.2 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Collected by Eliot Blackwelder and Li San.

Teinistion lansi Monke.

Plate 9, Figures 1, 1*a–b*.

Teinistion lansi Monke, 1903, Jahrb. königl. Preuss. Geol. Landesanstalt und Bergakademie, vol. XXIII, pt. 1, p. 117, plate 4, figs. 1–17; plate 9, fig. 3. (Species described and discussed as the genotype of the genus *Teinistion*.)

Doctor Monke states that this is the most abundant fossil on the slabs from Yen-tsy-yai. He gives a most elaborate description of the cranidium and free cheeks and portions of thoracic segments and pygidia which he refers to the species. We have reproduced a typical cranidium [fig. 1] and free cheek, [fig. 1*b*] for comparison with *Teinistion typicalis* [see plate 9, figs. 2, 2*a–b*].

The pygidia referred to this species by Doctor Monke are strongly characterized, but at the same time they are much like the pygidium named *Dicellocephalus? sinensis* by M. Bergeron [see plate 8, figs. 4 and 4*a*, of *Stephanocare ? sinensis* (Bergeron)]. The student is referred to the fine illustrations and description of Doctor Monke for further information.

Formation and Locality.—Middle Cambrian: Yen-tsy-yai, Shan-tung, China. Also (C 6), thin, platy limestone in the upper shale member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 41 (second list of fossils), and fig. 10 (bed 12), p. 38], 2.5 miles (4 km.) southwest of Yen-chuang, and (C 12) gray limestone near the top of the middle limestone member of the Kiu-lung group [idem (part of the first list), and fig. 10 (bed 7), p. 38], 3.25 miles (5.2 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Collected by Eliot Blackwelder and Li San.

Teinistion sodeni Monke.

Teinistion sodeni Monke, 1903, Jahrb. königl. Preuss. Geol. Landesansalt und Bergakademie, vol. XXIII, pt. 1, p. 123, vol. V, figs. 1–4. (Proposed species described and discussed.)

This species is probably founded on compressed and broken cranidia of *Blackwelderia sinensis* Bergeron.

Teinistion typicalis (Walcott).

Plate 9, Figures 2, 2*a–c*.

Dorypygella typicalis Walcott, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 29. (Species described and discussed.)

Cephalon transversely semicircular, moderately convex. Glabella truncato-conical, with the sides converging gently to the rounded front; three pairs of gla-

bellar furrows are indicated by slight, short depressions at the sides next to the dorsal furrow; back of the posterior pair of depressions a low, rounded ridge extends out onto the fixed cheek, forming a low, oval-shaped tubercle or lobe that is apparently the continuation of the postero-lateral lobe of the glabella; a small pit occurs just back of it, from which the occipital furrow starts; the latter is shallow, clearly defined, and extends slightly backward and then forward toward the center; occipital ring of medium width at the sides, broadening out to a somewhat flat, rather strong segment at the center; dorsal furrow obscure, and interrupted by the small lobe at the postero-lateral angle of the glabella, and by the palpebral ridge at its antero-lateral angle.

Fixed cheeks about two-thirds the width of the central portion of the glabella; they rise somewhat rapidly from the dorsal furrow to the palpebral lobe, and slope gently back to the posterior furrow and, in front of the palpebral ridge, rather rapidly to the furrow within the frontal rim; palpebral ridges strong and rather prominent; they originate against the antero-lateral angle of the glabella, extend obliquely backward across the fixed cheek, and merge into the rim of the palpebral lobe; palpebral lobe elevated above the fixed cheek, prominent, and about one-third of the entire length of the cephalon; a shallow groove extends from the thick, strong, broad, elevated rim down to the fixed cheek; postero-lateral limb about as long from the dorsal furrow to its extremity as the length of the glabella and occipital ring; a narrow furrow within the sharp posterior margin gives it an almost concave form; frontal border transverse or slightly incurved; it is elevated, rounded, and separated from the front of the glabella by a narrow, sharply defined furrow that extends outward and slightly forward between the rim and the fixed cheeks; it is nearly flat, broad at the center, narrowing toward the facial suture.

The associated free cheek is subrhomboidal in outline, with a narrow rim that is slightly flattened in front, becoming more rounded toward the postero-lateral angle, which has a short, sharp, backward-extending spine; the body of the cheek is slightly convex, rising broadly from the border to the base of the eye-lobe; the posterior border is short, being cut a short distance within the postero-lateral angle by the facial suture; the facial sutures, cutting the frontal limb, extend directly backward, with a slight outward curve, to the eye-lobe, around which they curve; back of the eye-lobe the sutures continue with a slight sigmoid flexure outward and backward, cutting the posterior margin a short distance within the postero-lateral angle.

The associated pygidium, which is doubtfully referred to this species, is transversely semicircular, with a short, conical, convex axis; the axis is divided by two narrow, shallow, transverse furrows into two anterior segments and a terminal segment about as long as the two anterior segments. Pleural lobes depressed, nearly flat for a short distance, and then sloping gently down to a narrow, flattened margin; they are marked by three shallow furrows, which separate a strong, anterior, narrow, elevated rim, two slightly convex segments, and a posterior segment at the end of the axis; the furrows and segments stop at the line of the flattened margin, with the exception of the anterior elevated rim, which continues across the margin and is extended into a strong spine that curves outward and backward; the border is narrow, slightly flattened, and transverse, but somewhat incurved posteriorly; it has four or more short, broad, backward-extending spines.

The surface of the central portions of the cephalon is apparently smooth under a strong lens, with the exception of a few scattered, depressed tubercles; the free cheeks have a few irregular, raised, inosculating lines extending from the base of the eye outward toward the rim; the surface of the associated pygidium appears to have a very few minute tubercles that can be seen only with the aid of a very strong lens.

The transverse front of the cephalon of this species suggests the cephalon of *Conocephalites frequens* Dames [1883, p. 7], but the glabella is entirely different in form. It differs from *Teinistion alcon* (Walcott) [p. 110] and *T. lansi* Monke [p. 111] by the narrower free cheeks and glabella and the form of the frontal rim.

Formation and Locality.—Middle Cambrian: (C12) Gray limestone near the top of the middle limestone member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 41 (part of the first list), and fig. 10 (bed 7), p. 38], 3.25 miles (5.2 km.) southeast of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Collected by Eliot Blackwelder and Li San.

Also from Locality (36f) Middle Cambrian: Fu-chóu series; about 1,000 feet (305 m.) above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general stratigraphic relations]; collected in a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria, China.

Collected by J. P. Iddings and Li San.

Genus STEPHANOCARE Monke.

Stephanocare MONKE, 1903, Jahrb. königl. Preuss. Geol. Landesanstalt und Bergakademie zu Berlin, vol. XXIII, pt. 1, p. 136. (Genus described and discussed under species *S. richthofeni*.)

Damesella WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 34. (Includes the genotype of *Stephanocare*, as a new species under *Damesella*.)

The description of this genus was included in that of the type species, *S. richthofeni* Monke. When studying, in 1905, the Cambrian fossils collected by the Carnegie Institution of Washington Expedition I was unaware of the existence of Herr Monke's paper, and named the type of this genus *Damesella chione*, stating that the pygidium differed from the pygidium of *Damesella blackwelderi* in having its anchylosed segments extending out directly across the border in the falcate spinose ends. A further study of all the material in the collection, and Herr Monke's illustrations, lead me to consider that *Stephanocare richthofeni* Monke represents a different genus from *Damesella bellagranulata*, but as yet we do not know the pygidium of that species, or the free cheeks.

Genotype.—*Stephanocare richthofeni* Monke.

Two other species are doubtfully referred to *Stephanocare*, *S. ? monkei* Walcott and *S. ? sinensis* (Bergeron). I think that with the discovery of entire specimens it will be found that they belong to quite distinct genera. *Stephanocare ? monkei* may go to *Blackwelderia* and *S. ? sinensis* prove to be the type of a new genus.

Stephanocare ? monkei Walcott.

Plate 8, Figure 5.

Stephanocare sp. MONKE, 1903, Jahrb. königl. Preuss. Geol. Landesanstalt und Bergakademie, vol. XXIII, pt. 1, p. 144, plate 7, figs. 1, 1*a*, 2–4. (Describes and illustrates a pygidium.)

Stephanocare ? monkei WALCOTT, 1911, Smithsonian Misc. Coll., vol. 57, No. 4, p. 77, plate 14, fig. 7. (Described and discussed as a new species essentially as below.)

Doctor Monke doubtfully refers a cephalon, two pygidia, and a free cheek to *Stephanocare*. Similar pygidia occur on the platy limestones collected by Mr. Blackwelder, and as they are clearly distinct from any described species I give them the specific name of *S. ? monkei* in recognition of the excellent work done by Doctor Monke on this interesting fauna. The generic reference is in doubt, as we have no entire specimens of *Stephanocare richthofeni* Monke and of this species for comparison.

Formation and Locality.—Middle Cambrian: (C6) Thin, platy limestone in the upper shale member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 41

(second list of fossils), and fig. 10 (bed 12), p. 38], 2.5 miles (4 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Collected by Eliot Blackwelder.

Stephanocare richthofeni Monke.

Plate 7, Figures 17, 17*a–f*.

Stephanocare richthofeni Monke, 1903, Jahrb. königl. Preuss. Geol. Landesanstalt und Bergakademie, vol. xxiii, pt. 1, p. 136, plate 7, figs. 1–15. (Species described and discussed as a new species and the genotype.)

Damesella chione Walcott, 1905, Proc. U. S. Nat. Mus., vol. xxix, p. 40. (Species described and referred to *Damesella*.)

Of this species there are several well-preserved central portions of the cephalon, free cheeks, and pygidia.

The cephalon is transversely semicircular, moderately convex. Glabella convex, truncato-conical, rounded in front; the length is slightly greater than the width at the base; a posterior pair of glabellar furrows extends inward and obliquely backward a short distance, so as to outline a small, oval, slightly convex lobe at the postero-lateral angles; a second pair of very slightly impressed, short glabellar furrows occurs about half way between the posterior furrows and the front; and a third pair of furrows is indicated on some examples; occipital furrow narrow, transverse, clearly defined; occipital ring narrow at the sides; increasing in width toward the center, slightly convex, and a little elevated at the back; the posterior margin shows a number of short, strong spines; the largest number seen is eight, four on each side of the center; dorsal furrow narrow and distinct.

Fixed cheeks about one-half the width of the glabella at the base, and moderately convex; they round up from the dorsal furrow and are nearly flat out to the palpebral lobe, back of the line of which they slope gently to the furrow of the postero-lateral limb, and in front more abruptly to the furrow within the front margin; palpebral lobe a little more than one-third the length of the cephalon, narrow, distinct, but not rising above the general level of the fixed cheek; palpebral ridge indicated only by a very narrow, smooth line between the anterior end of the palpebral lobe and the dorsal furrow; postero-lateral limb narrow and extending out a considerable distance to a rather blunt, rounded end; its posterior margin is ornamented with short, strong spines, that are usually broken away; front margin of the cephalon badly preserved; it appears to have been short, rounded, and separated from the glabella and fixed cheeks by a narrow furrow.

Free cheeks subtriangular in outline, with a distinct, narrow, slightly elevated border and a sharp postero-lateral spine; the posterior border within the genal spine has three or four short, strong spines corresponding to the spines of the posterior border of the central portions of the cephalon; the outer margin was provided with short, strong spines that are usually broken off from the specimens in the collection; from the base of the spine an inner flattened border originates and narrows to a point below the front of the eye-lobe; it is defined by a narrow furrow within the sharp rim, and the furrow between it and the central portion of the cheek; it is marked by granules in the same manner as the body of the cheek; the narrowing and disappearance of the flat border, leaving only the narrow rim at the facial suture, indicate that the border in front of the fixed cheeks of the glabella was very narrow; body of the cheek moderately convex, rounding up from the furrow at its base to the base of the strong eye-lobe; the facial suture extends with a slightly sigmoid curve from the posterior base of the eye-lobe outward and backward to the furrow within the rather broad posterior margin of the free cheek; it there cuts directly

across the lobe, leaving a short portion of the broad margin extending obliquely forward and outward at the base of the postero-lateral spine; in front of the palpebral lobe the facial suture extends forward and slightly outward to the front margin.

There are several specimens of a hypostoma associated with the species, that appear to belong to it. The central portion is convex, subovate, and crossed toward the front by a strong furrow subparallel to the rounded front margin; a narrow rim surrounds the front and expands into two ear-like, flattened projections opposite the strong furrow crossing the central portion; the margin then contracts so as to leave a narrow, rounded rim opposite the convex portion of the posterior part of the central body; it then expands so as to form a subtriangular limb on each side at the postero-lateral angles of the hypostoma. The hypostoma is of the same type as that of *Damesella blackwelderi* [plate 10, fig. 1*i*].

The associated pygidium is transversely semicircular, with a spinose margin and convex, conical axis; the axis is divided into five rings and a subtriangular terminal portion by five transverse furrows; the two anterior rings are rather convex, while the three posterior are but slightly defined by shallow, narrow, transverse furrows. The pleural lobes are slightly convex out to the geniculation, where the slope is somewhat abruptly downward to the end of the falcate termination of the segment outline on the lobe; the furrows crossing the axis extend out on the pleural lobes, so as to define a narrow anterior segment and four posterior segments and a central portion extending down from the axis; each of the segments terminates in a falcate, backward-curving, short, flat spine, of which there are six on each side, one for each of the segments and two back of the axis; there does not appear to be any clear indication of a border, as the space is occupied entirely by the segments and their falcate ends.

The surface of the glabella, fixed cheeks, free cheeks, and occipital ring is marked by numerous, rather closely set, depressed pustules, between and on which there are very fine punctæ, as determined by a strong lens. The surface of the pygidium is marked by strong pustules or granules that are thickly set on the segments but not on the furrows. There appears to be considerable difference in the strength and size of the granules on different specimens. This may be simply a matter of the state of preservation, or the amount of wear to which the crust has been subjected, or it may indicate a variety or even a different species.

A cephalon 3 mm. in length has a width of 5 mm. at the exterior of the palpebral lobes, and a width at the base of the glabella of 2 mm.

The pygidium illustrated by M. Bergeron as *Dicellocephalus ? sinensis* Bergeron [1899, p. 508], which occurs at this same stratigraphic horizon in China, appears to resemble more closely than any other form the pygidium of this species. As illustrated and described by M. Bergeron, it differs from *Stephanocare richthofeni* in its shorter axis, five instead of six spines on the margin, and a smooth instead of a granulose surface. *Stephanocare richthofeni* has a cephalon of essentially the same type as that of *Damesella blackwelderi* [p. 125], but the pygidium differs in having its anchylosed segments extending out directly across the border into the falcate spinose ends, instead of stopping within the border and having spines representing the extension of the segments extending outward from the border.

Specimens of *Drepanura premesnili* Bergeron [1899, p. 509] and *Agnostus douvillei* Bergeron [1899, p. 503] are associated with *Stephanocare richthofeni;* and *Liostracina krausei* Monke, *Teinistion lansi* Monke, and *Shantungia spinifera* Walcott [p. 148] occur at the same horizon and in many instances on the same hand specimen with *Stephanocare richthofeni.*

Formation and Locality.—Middle Cambrian: (C6) Thin, platy limestone in the upper shale member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 41 (second list of fossils), and fig. 10 (bed 12), p. 38], 2.5 miles (4 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung; also (C55), just below the Ch'au-mi-tién limestone in the Ku-shan shales [idem, p. 43], in isolated hills at an elevation of 380 feet (114 m.) above the Wön-ho, 12 miles (19 km.) south 80° east of Tsi-nan, Shantung, China.

Collected by Bailey Willis and Eliot Blackwelder.

Stephanocare ? sinensis (Bergeron).

Plate 8, Figures 4, 4*a*.

Dicellocephalus ? sinensis BERGERON, 1899, Bull. Soc. Geol. de France, 3d ser., vol. XXVIII, p. 508, text-fig. 7, vol. VIII, fig. 7. (Describes and illustrates pygidium.)

Damesella sinensis WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 35. (Places *Dicellocephalus ? sinensis* Bergeron as *Damesella sinensis* (Bergeron).)

M. Bergeron founded this species on specimens of a pygidium that occur on the same surface of platy limestone as *Stephanocare richthofeni* in the collection made by Mr. Blackwelder. It is probable that the pygidia belong to the genus, but in the absence of the cephalon the generic reference is more or less doubtful. Collections that are now being made for me in the Sin-t'ai district may, when received, clear up not only this but several other doubtful generic references. In Manchuria it is associated with several of the species found with it about Yen-chuang.

Doctor Monke has illustrated several pygidia [Monke, 1903, plate 4, figs. 12–17], and referred them to *Teinistion lansi* Monke, that appear to belong to this species.

Formation and Locality.—Middle Cambrian: (C6) Thin, platy limestone in the upper shale member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 41 (second list of fossils), and fig. 10 (bed 12), p. 38], 2.5 miles (4 km.) southwest of Yen-chuang, Sin-t'ai district, Shantung, China.

Collected by Eliot Blackwelder.

Also from Locality 36f, Fu-chóu series; about 1,000 feet (305 m.) above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general stratigraphic relations]; collected in a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria, China.

Collected by J. P. Iddings and Li San.

Stephanocare ? sp. undt.

Plate 8, Figure 6.

This is a small pygidium that differs from the pygidium of *S. ? monkei* Walcott [p. 113] in having marginal spines of a more nearly uniform character.

Formation and Locality.—Middle Cambrian: (C6) Thin, platy limestone in the upper shale member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 41 (second list of fossils), and fig. 10 (bed 12), p. 38], 2.5 miles (4 km.) southwest of Yen-chuang, Sin-t'ai district, Shantung, China.

Collected by Eliot Blackwelder.

Genus BLACKWELDERIA Walcott.

Blackwelderia WALCOTT, 1906, Proc. U. S. Nat. Mus., vol. XXX, p. 573. (Mentioned as a new genus.)

Cephalon transversely semicircular, with the postero-lateral angles rounded or spiniferous; the anterior and lateral margins have a thickened or elevated border within which there is a concave slope or a narrow furrow. Glabella truncato-

conical, marked by two or more pairs of short furrows; occipital furrow clearly defined; occipital ring rounded. Fixed cheeks rather broad and convex. Free cheeks subtriangular in outline, rising from the border to the eye-lobe with a gentle convexity; a spine is attached to the lateral border a short distance in advance of where the border is cut by the facial suture. Facial suture, cutting the anterior border nearly on a line with the front base of the eye-lobe, extends obliquely across the border, and then with slight curvature to the palpebral lobe; curving about the latter, it extends obliquely outward and backward, cutting the border at the postero-lateral angle of the cephalon, and back of the spine extending from the border. Eyes small, elevated, and situated about midway of the distance between the front and posterior margins of the cephalon.

The associated hypostoma of *B. sinensis* has a subrhomboidal outline; convex, oval body with a transverse, curved furrow; the narrow, rounded border incloses a small wing-like projection opposite the central body.

Number of thoracic segments unknown. Segments associated with *B. sinensis* have a strong central axis less than one-half the width of the pleural lobes; pleural lobes flattened about two-thirds the distance from the axis to the end of the segment; a flat groove begins near the axis and extends with a nearly uniform width to the genal angle, where it narrows to the base of the spinose or falcate termination of the segment.

The pygidium associated with *B. sinensis* has a subsemicircular outline; axis convex, strong, and divided into four or more transverse rings by transverse furrows; lateral lobes depressed and divided by strong furrows into four or more segments that cross the border and continue as spines of varying strength and length; border rounded and somewhat obscured by merging into the segments and the spines on its outer margin.

Surface granular in the type species.

This genus differs from *Damesella* Walcott, to which it appears to be most nearly related, in having a flat, straight groove on the pleural lobe of the segments of the thorax, proportionately broader furrows on the pleural lobe of the pygidium, and a concave frontal limb on the cephalon with a narrow rim. *Blackwelderia* differs from *Teinistion* Monke mainly in the character of the associated free cheeks and pygidia and the frontal limb of the cephalon. It differs from *Dorypyge* Dames in the form of the glabella and free cheeks. The straight groove of the pleural lobe of the thoracic segments is much alike in the two genera and the pygidia are of the same type. The thoracic segments of *Blackwelderia* are of the same type as those of *Olenellus* Meek, but the cephalon differs in the glabella. From *Stephanocare* Monke it differs in the character of the frontal border of the cephalon and the pleural lobes of the pygidium, as well as the pleural lobes of the thoracic segments.

Genotype.—Calymmene ? sinensis Bergeron; second species, *B. cilix* (Walcott); third species, *B. alastor* (Walcott).

Blackwelderia alastor (Walcott).

Plate 9, Figures 7, 7*a*.

Dorypygella alastor Walcott, 1905, Proc. U. S. Nat. Mus., vol. xxix, p. 31. (Described and discussed as a new species essentially as below.)

This species is represented by a single specimen of the central portions of a moderately convex cephalon and several associated pygidia that occur at the same horizon as *Teinistion alcon* [p. 110]. Cephalon, as indicated by the specimen, transversely semicircular and moderately convex. Glabella broadly truncato-conical, narrowing to the gently rounded front; two pairs of narrow, short furrows extend

obliquely inward and backward; the posterior pair outlines a rather large postero-lateral lobe, which is confluent with an oval-shaped lobe that interrupts the dorsal furrow and on one side merges into the fixed cheek; a second pair of furrows outlines a small, narrow lobe that is scarcely separated from the fixed cheek by the dorsal furrow; occipital furrow narrow, transverse; occipital ring broken away; dorsal furrow slightly outlined in front and at the antero-lateral angles of the glabella, and practically non-existent back of that at the sides, owing to interruption by the merging of the lobes of the glabella and the fixed cheeks.

Fixed cheeks nearly as wide as the anterior portion of the glabella, interrupted by strong, low palpebral ridges that originate at the antero-lateral angles of the glabella and extend obliquely outward and backward to the palpebral lobes; palpebral lobes large, about one-half the length of the cephalon, and rising abruptly from the nearly flat fixed cheek; their outer margin is broad, rounded, elevated, semicircular, with a deep groove sloping down to the fixed cheek; frontal limb very narrow, merely a rounded line between the glabella and the flat frontal rim; to the sides it merges into the strong palpebral ridge and downward slope of the fixed cheek in front of the ridge; frontal rim narrow, nearly flat, and rising to the slightly rounded margin.

Surface apparently smooth, with the exception of a few small, scattered pustules on the glabella.

At this same locality and horizon, and in limestone of the same character but not in the same hand specimen, there are a number of pygidia which appear to possess characteristics distinct from those of any described species and which have been referred to *B. alastor*. They are transversely semicircular in form, exclusive of the spines on the border. Axis elongate conical, convex, divided by five shallow furrows into five transverse, very slightly convex rings, and a terminal section a little longer than the greatest width of any ring; the terminal section ends somewhat abruptly and slopes rapidly downward to the margin; it is marked at the point where it slopes downward by a small node each side of the center. Dorsal furrow very slight, as the pleural lobes are nearly flat but slightly convex before reaching the margin.

The pleural lobes are divided by five shallow furrows into five rounded segments and a narrow frontal rim or segment and a posterior, obscure segment; the furrows and segments, with the exception of the anterior furrow and segment, terminate at the inner margin of the border; the anterior furrow crosses the border, and the anterior segment is continued out across the border, merging into the anterior spine. Border flat, distinctly defined except opposite the anterior segment, and bordered with a series of marginal spines; these include a long anterior spine, which is a continuation of the anterior margin and a part of the first segment; back of this there are four pairs of short spines which may be considered in a general way as opposite the four anterior segments; the sixth pair of spines project backward; they are long, broad, flat, and opposite the obscure terminal segment of the pleural lobe; between the two large spines, opposite the dorsal furrow at the side of the axis, are two short spines; all of the spines are more or less flat and merge directly into the flat border, with the exception of the two anterior, which are connected with the anterior segment and frontal rim.

The surface of the rings and segments is marked by minute granules; otherwise it appears to be smooth under a strong lens.

A specimen 7 mm. in length has a width of 12 mm., exclusive of the spines; axis, 3 mm. in width in front, 1.75 mm. at the posterior end; pleural lobe back of the first segment, 3 mm. in width.

This species differs from *Damesella blackwelderi* [plate 10, figs. 1, 1*a–f*] in having a broader and more tapering glabella, a thin frontal rim, and a narrow frontal limb. The pygidium referred to *B. alastor* has a more slender axis, flatter border, two spines fewer on the margin, and two of the posterior spines of greater length. The cephalon of *B. alastor* is much like that of *Teinistion typicalis* [plate 9, figs. 2, 2*a–c*], but it differs in the character of the frontal rim and the associated pygidium. *Teinistion alcon* [plate 9, fig. 3] has a much broader fixed cheek and a different frontal rim.

It is difficult to make a satisfactory generic reference of this species, as it has characters of both *Blackwelderia* and *Teinistion*. It is referred to the former genus on account of the associated pygidium.

Formation and Locality.—Middle Cambrian: (C12) Gray limestone near the top of the middle limestone member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 41 (part of the first list), and fig. 10 (bed 7), p. 38], 3.25 miles (5.2 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Collected by Eliot Blackwelder and Li San.

Blackwelderia cilix (Walcott).

Plate 9, Figures 6, 6*a–c*.

Olenoides (?) cilix Walcott, 1905, Proc. U. S. Nat. Mus., vol. xxix, p. 27. (Described and discussed as a new species.)

Blackwelderia cilix (Walcott), 1906, idem, vol. xxx, p. 573. (Description of species extended and more thoroughly discussed.)

This species is represented by numerous specimens of the central portions of the cephalon, separated free cheeks, and associated specimens of the pygidium.

These indicate that the general form of the cephalon was transversely semicircular and rather strongly convex, and that the margin of the cephalon was of medium width in front, gradually widening to the free cheek, where it narrows toward the base of the postero-lateral spine. A postero-lateral spine projects backward and slightly upward from a point on the margin a little in advance of the postero-lateral angle. Glabella truncato-conical in outline, and marked by three pairs of furrows, the posterior of which extends obliquely backward nearly to the occipital furrow; the anterior furrows are indicated by short, slight depressions on the edges of the glabella next to the dorsal furrow; they are situated so as to divide the space between the posterior furrows and the front margin of the glabella into subequal spaces; a very narrow, slightly indicated, median, longitudinal ridge extends from the occipital furrow nearly to the front of the glabella; occipital furrow strongly marked, rounded, and about as wide as the occipital segment; occipital segment of medium width, convex, and arching forward slightly at the center; a shallow furrow crosses it on each side so as to outline a rounded node at each end; dorsal furrow rounded, rather strong at the ends, and merging into the broad, concave slope of the frontal limb.

Fixed cheeks about one-half the width of the glabella; they rise abruptly from the dorsal furrow to the base of the palpebral lobes and slope rapidly from the palpebral lobes backward to the posterior furrow and more rapidly to the front, where they merge into the concave frontal limb; palpebral lobes small, elevated, separated from the fixed cheeks by a shallow furrow, and situated opposite the central part of the cephalon; palpebral ridges indicated by depressed lines that extend from the anterior end of the palpebral lobe, across the fixed cheeks, to the dorsal furrow; postero-lateral limb about one-third the width of the cephalon within the facial sutures; it is marked by a broad, shallow furrow within the narrow posterior

margin; frontal limb broad, concave, and rising with a gentle curvature from the front of the glabella to the margin of the thickened frontal rim.

Free cheek roughly subtriangular; it is divided into an interior convex body, which rises from the furrow at its base to the small eye-lobe at its center; the border of the cheek is crossed obliquely by a sharp ridge that extends from its inner, anterior side backward to its outer side, where it forms the outer edge of a sharp spine; the border extends backward, but not so as to form the genal angle of the cheek; a strong, sharp spine originates a little in advance of the facial suture and extends obliquely backward.

The type pygidium of this species was described as follows:

Pygidium semicircular in outline, moderately convex, and with a spinose margin; axis moderately convex, conical, with a broadly rounded posterior end; it is divided by three clearly marked, transverse rounded furrows into a strong anterior ring, next to the thorax, two moderately convex rings, and a long terminal portion, which has a slight fourth depression, indicating a fourth ring; the posterior portion of the axis slopes rather rapidly down to the margin; owing to an abrasion, the presence or absence of additional rings or nodes usually present at the end of the axis can not be determined. Dorsal furrow rounded and shallow.

Pleural lobes flat for a short distance from the axis, and then curve gently downward to the border; they are marked by a deep anterior furrow within the narrow, anterior, elevated margin, and three furrows that terminate at the margin; the furrows outline three rather broad, slightly convex segments and a posterior area opposite the postero-lateral angle of the axis. The border is practically a continuation of the slope of the segments and furrows of the pleural lobe; it is marked opposite the segments by five short, backward-pointing, flat, broad spines, and diagonally opposite the lateral angle of the axis by two long, strong, backward-extending spines; in addition, there are two short spines with broad bases back of the axis between the two long spines. [Walcott, 1905*b*, p. 27.]

In a collection from another locality specimens of the pygidium show considerable variation. On the larger specimens the axis is divided by four well-defined, strong transverse furrows and a fifth furrow is indicated by a shallow depression across the terminal section; the furrows divide the axis into five segments or rings, and the subtriangular terminal portion that slopes rapidly from its center to the thickened border; lateral lobes broad, convex, and marked by a narrow, anterior, elevated segment, which joins the thorax, and three strong, narrow, elevated ridges, and a small node indicating a fourth ridge; the ridges are separated by broad, strong furrows that are continuations of the furrows crossing the axis; the thickened border is separated from the body of the pygidium by a shallow groove.

Surface of the crust of the cephalon, free cheeks, pygidium, and associated fragments of the segments of the thorax, minutely punctate.

The largest cephalon in the collection has a length of 20 mm., with the same width at the palpebral lobes; the largest pygidium has a width of 35 mm. and a length of 18 mm., exclusive of the spines.

This species was founded on a pygidium from the Ku-shan shale zone in Shantung. A year later the same specific form of pygidium was observed in a new lot of material from the Ku-shan shale horizon of Shan-si. With the Shan-si specimens numerous cephala and free cheeks occur that are considered to belong to this species, as there are no other forms occurring in the same rock to which the pygidia could be referred.

The cephalon of this species differs from that of *Blackwelderia sinensis* [plate 9, figs. 5, 5*a*–*b*] in having a longer frontal limb, narrower fixed cheeks, and smoother

surface. The pygidium of *B. cilix* [plate 9, figs. 6*b–c*] differs from that of *B. sinensis* [plate 9, figs. 5*e*, 5*g*] in having the sixth spine on each side much longer than the others, also in having a stronger axial lobe and less distinctly defined border. The comparison of *B. cilix* with species referred to the genus *Teinistion* is referred to under the description of the genus *Blackwelderia*.

Formation and Locality.—Middle Cambrian: (C55) Just below the Ch'au-mi-tién limestone in the Ku-shan shales [Blackwelder, 1907*a*, p. 43], in isolated hills at an elevation of 380 feet (114 m.) above the Wön-ho, 12 miles (19 km.) south 80° east of Tsi-nan, Shan-tung; also (C73), conglomeritic limestones near the top of the Ki-chóu limestone [Willis and Blackwelder, 1907, p. 145, fourth list of fossils], 4 miles (6.4 km.) east of Fang-lan-chön, Shan-si, China.

Collected by Bailey Willis and Eliot Blackwelder.

Blackwelderia sinensis (Bergeron).

Plate 9, Figures 5, 5*a–g*.

Calymmene ? sinensis BERGERON, 1899, Bull. Soc. géol. de France, 3d ser., vol. XXVII, p. 500, plate 13, figs. 1, 2, and text figs. 1, 2, p. 501. (Species discussed and described from fragments of cranidium.)

Olenoides leblanci BERGERON, 1899, idem, p. 506, plate 13, figs. 5, 6, and text-figs. 5, 6, p. 506. (Species discussed and described from pygidium.)

Stephanocare sinensis MONKE, 1903, Jahrb. königl. Preuss. Geol. Landesanstalt und Bergakademie, vol. XXIII, pt. 1, 1902, p. 142. (Discusses species.)

Blackwelderia sinensis (Bergeron), WALCOTT, 1906, Proc. U. S. Nat. Mus., vol. XXX, p. 573. (Places *Calymmene ? sinensis* Bergeron as the type of the genus *Blackwelderia*.)

Cephalon transversely semicircular, rather strongly convex, most elevated at the palpebral lobes; frontal border or rim nearly transverse in front of the glabella, rounding gently to the postero-lateral angles; it is narrow and somewhat elevated in front, becoming more rounded at the sides; it continues around the postero-lateral angle to unite with a narrow, slightly defined posterior border. A postero-lateral spine projects backward and slightly upward from a point on the margin a little in advance of where the facial suture cuts the margin.

Glabella large, truncato-conical in outline, and marked by a posterior pair of furrows that extend obliquely inward so as to outline a small triangular lobe that is connected by a low ridge with the fixed cheek; the middle pair of furrows is short and slightly impressed; the anterior pair of furrows is very short, and usually not clearly defined; occipital furrow transverse, rounded, of medium width, and not very deep; occipital ring of medium width, curving slightly forward toward the sides, and gently convex; dorsal furrow clearly defined at the sides of the glabella except at the ridge connecting the posterior lobe of the glabella and the fixed cheek, where it is very shallow in most specimens; in front of the glabella there is little more than an angle formed by the union of the downward slope of the glabella and the outward slope of the frontal limb.

Fixed cheeks nearly as wide as the glabella opposite the palpebral lobes; they rise from the dorsal furrow to the palpebral lobes and slope with a gentle curvature downward to the frontal limb and extend with a very slight slope to the strong furrow within the posterior margin; a slightly defined palpebral ridge starts from the anterior margin of the palpebral lobe and extends part way across the fixed cheek before disappearing; postero-lateral limb about one and one-half times as long as the width of the glabella at its base, and back of the palpebral lobes a little more than one-third the length of the cephalon; palpebral lobes about one-fourth the length of the cephalon, elevated at the outer border and quite prominent; frontal limb narrow,

slightly convex, rising to meet the frontal rim so as to form a rounded angle with the latter; frontal rim or border narrow and nearly flat.

The facial sutures cut through the frontal rim of the cephalon obliquely and then extend almost directly backward to the anterior rim of the palpebral lobe; curving around the latter, they pass obliquely outward and backward, cutting the border of the cephalon a little back of the postero-lateral angle.

Associated free cheek subtriangular in outline; the border is well defined and extends to the facial suture; it is interrupted in advance of the facial suture by a strong backward extending spine; the body of the cheek rises with a gentle convexity to the base of the eye-lobe.

The associated hypostoma is subrhomboidal in outline, with the central portion or body oval and convex; the latter is crossed by a curved furrow a short distance from its posterior margin; a well-defined rim extends across the posterior margin, with a furrow between it and the body; at the sides the rim incloses on each side an ear-like projection which is about one-third the length of the hypostoma; the margin incurves slightly back of the ear-like projection and then curves outward to join the frontal margin so as to form a rather sharp, pointed angle.

The associated thoracic segments have a strongly convex axis which is about one-half the width of the pleural lobe; the axis is marked on each side by a shallow furrow near its front margin; whether there was a median spine present or not is unknown; the pleural lobes are nearly flat to the genal angle, where they curve somewhat gently downward; they are marked by a broad, flat furrow that is nearly the same width from the inner side next to the axis out to the genal angle; at the genal angle the furrow narrows gradually to where it disappears upon the falcate termination.

Pygidium large, semicircular; axial lobe convex and tapering gradually; it is divided by rather narrow furrows into five segments and a terminal portion which is usually about as long as broad; the terminal portion has two small nodes near the posterior side just before the steep downward slope to the posterior border; pleural lobes broad, slightly convex, and marked by a narrow anterior segment and four strong segments that are separated by five broad furrows that terminate within the border; the border is interrupted by a slight depression between each of the segments, but it is fairly well defined; on its outer margin it carries seven rather strong spines; the first six on each side may be correlated with the ridges or segments on the pleural lobes; the two posterior are opposite the small nodes on the posterior termination of the axis.

The surface of the crust of the cephalon is marked by a minutely granulose surface with a few large scattered tubercles; a number of the larger tubercles occur along the posterior rim, giving an almost dentate or spinose outline to the latter; the segments of the thorax appear to have been marked by a similar surface, as well as that of the pygidium.

The largest cephalon in the collection has a length of 17 mm., and the largest pygidium 20 mm., exclusive of the spines on the border.

The cephalon of this species suggests at once that of *Teinistion typicalis* (Walcott) [plate 9, figs. 2, 2*a*]. It differs in the character of the frontal limb and border of the cephalon. The associated free cheek and pygidium also differ radically. From *Damesella blackwelderi* [plate 10, figs. 1, 1*c*], the cephalon differs in the character of the frontal limb and border, and the associated thoracic segment is of a different type. It is distinguished by its straight furrow on the pleural lobe, while in *D. blackwelderi* the furrow is oblique; the associated pygidia are essentially of the same type. From all species of *Dorypyge* [plate 8] and *Olenoides* this species differs in

the character of the glabella and the form of the associated pygidium; the straight, flat furrow on the pleural lobes of the thoracic segments is of the same type as that of *Olenoides* and *Dorypyge* [plate 8].

The species differs from *Blackwelderia cilix* [plate 9, figs. 6, 6*a*–*b*] in the character of the frontal limb, its broader fixed cheeks, and in the form and character of the spinose border of the pygidium.

M. Bergeron described his *Calymmene ? sinensis* from a few specimens of the central portions of the cephalon, and his *Olenoides leblanci* from specimens of a pygidium associated with the cephala. The much better material now available for study indicates that the cephala and pygidia belong to the same species, and I therefore unite them under the term *B. sinensis*, as that name occurs first in order in M. Bergeron's paper.

For comparisons between this species and *B. cilix* see observations under that species [p. 119].

Formation and Locality.—Middle Cambrian: (C6) Thin, platy limestone in the upper shale member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 41 (second list of fossils), and fig. 10 (bed 12), p. 38], 2.5 miles (4 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Collected by Eliot Blackwelder.

Also from Locality 36f, Middle Cambrian: Fu-chóu series; about 1,000 feet (305 m.) above the white quartizte [see Blackwelder, 1907*b*, p. 92, for general stratigraphic relations], collected in a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria, China.

Collected by J. P. Iddings and Li San.

Genus DAMESELLA Walcott.

Damesella Walcott, 1905, Proc. U. S. Nat. Mus., vol. xxix, p. 34. (Genus described and discussed.)

General form elongate, ovate, distinctly trilobate, moderately convex. Cephalon transversely semicircular, with the postero-lateral angles rounded or spiniferous; the anterior and lateral margins have a thickened or elevated border, within which there is a well-marked furrow. Glabella truncato-conical, marked by two or more pairs of short furrows; occipital furrow strongly defined; occipital ring rounded. Fixed cheeks rather broad. Free cheeks subtriangular in outline, rising with a gentle curvature to the base of the eye-lobe; the border is extended into a lateral spine a short distance in advance of where it is cut by the facial suture. The facial suture, cutting the anterior border nearly opposite the base of the inner margin of the palpebral lobe, extends with slight curvature backward to the palpebral lobe; curving about the latter, it extends outward and backward, cutting the posterior margin a little in front of the rounded postero-lateral angle. Eyes small, elevated, and situated about midway of the glabella.

Hypostoma subrhomboidal in outline; central portion strongly convex, elevated, with an irregular border at the back and sides, broadening out in front to a greater width than at the back.

Thorax with twelve or more transverse segments; axis about one-third the width of the thorax, gradually narrowing posteriorly. Pleuræ nearly horizontal, at right angles to the axis out to the point where they curve gently backward before terminating in a falcate extremity; pleural groove long, deep, and broad, starting at the dorsal furrow near the front and extending out on the falcate end.

Pygidium subsemicircular; axis convex, broadly conical, and divided into four or more rings by transverse furrows; lateral lobes depressed, convex, and divided

by furrows into four or more segments; border rounded, and bearing five or more spines on each side.

Surface in the type species granulose.

Genotype.—Damesella blackwelderi Walcott.

The species referred to the genus are *Damesella bellagranulata* Walcott, *D. blackwelderi* Walcott, and *D. brevicaudata* Walcott.

This genus differs from *Dorypyge* [plate 8], with which it appears to be most nearly related, in the character of the cephalon; the thorax and pygidium are essentially of the same type, as far as fragments of *Dorypyge* can be compared with *Damesella*. The pygidium of *Damesella* is similar in type to that of *Olenoides* Meek [plate 8] and *Neolenus* Matthew [Walcott, 1908*b*, plates 4–6], and the pleural lobes of the thoracic segments are of the same type as those of *Neolenus*, but the thorax of *Olenoides* and *Neolenus* has seven segments and a strong median spine on the axis, while the thorax of *Damesella* has twelve or more segments and is without a median spine; from what is known of the cephalon of *Olenoides* it is of the same character as that of *Dorypyge* [plate 8].

The genus *Dinesus* Etheridge Jr. [1896, p. 56, plate 1, figs. 1–5], appears to be more nearly related to *Dorypyge* Dames than to *Damesella* or *Teinistion* Monke. Its marked characteristics are the elongate, oval glabella, with the small, distinct, antero-lateral and postero-lateral lobes, the small palpebral lobes, and the large pygidium with a spinose border. Only one species is known—*Dinesus ida* Etheridge Jr.

The genus *Stephanocare*, described by Herr Monke in 1903,[1] was founded on the species *Stephanocare richthofeni*, subsequently described by me as *Damesella chione* Walcott [1905*b*, p. 40]. The latter was the fourth species referred to *Damesella* by Walcott. Attention was then called to the difference in the pygidium of *Damesella chione* (=*Stephanocare richthofeni*) when compared with the pygidium of *Damesella blackwelderi*, the type of the genus *Damesella*. [See plate 7, figs. 17*c–e*, of *Stephanocare richthofeni* Monke, and plate 10, figs. 1*e–f*, of *Damesella blackwelderi*.] The general contour of the cephalon and the direction of the facial sutures in the two species are much alike, but the spinose margins of the cephalon of *S. richthofeni* and the sharp spines over the surface of the cephalon, thorax, and pygidium are a strongly marked feature of that species. This character and the difference in the pygidia of the two species indicate different generic relations. With the exception of a few fragments, the thorax of *S. richthofeni* is unknown.

Under the definition of *Proparia* Dr. C. E. Beecher [1897, p. 198] gives as an original character "Free cheeks not bearing the genal angles," and under *Opisthoparia* he says: "Free cheeks generally separate, always bearing the genal angles" [1897, p. 187]. In *Damesella* and *Stephanocare* the facial suture cuts the postero-lateral margin outside of the genal angle, so as to leave the genal angle on the fixed cheeks, and, at the same time, the spine corresponding to the genal spine in other genera of the order *Proparia* on the free cheek. In other characters *Damesella* and *Stephanocare* belong with the *Proparia*, and I think that the definitions of the orders *Proparia* and *Opisthoparia* need to be modified in relation to the exceptions made by *Damesella* and *Stephanocare* in the position of the genal angle on the fixed cheek.

[1]When preparing the preliminary notes on the Cambrian faunas of China [Proc. U. S. Nat. Mus., vol. XXIX, pp. 1–106, Sept. 1905] in 1905, I had not noticed that Herr H. Monke had published a paper on the Geology of Shan-tung, and described certain Upper Cambrian trilobites. [Beiträge zur Geologie von Schantung. I. Obercambrische Trilobiten von Yen-tsy-yai. Jahrb. königl. Preuss. Geol. Landesanstalt und Bergakademie zu Berlin, vol. XXIII, pt. 1, 1903, pp. 103–151.] It was not until February 27, 1906, that the Jahrbuch containing the paper arrived at the U. S. Geological Survey Library.

Damesella bellagranulata Walcott.

Plate 9, Figures 8, 8*a–b*.

Damesella bellagranulata WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 38. (Described and discussed as a new species essentially as below.)

This species is represented by the central portions of the cephalon, exclusive of the free cheeks. These parts indicate that the cephalon was transversely semicircular and moderately convex. Glabella truncato-conical, moderately convex, and marked by two pairs of very faintly indicated, short furrows; occipital furrow narrow, transverse, clearly defined; occipital ring of moderate width and slightly convex; dorsal furrow clearly defined on the sides of the glabella; frontal border narrow, rounded.

Fixed cheeks of nearly the same width as the glabella opposite the palpebral lobes; they slope up very slightly from the dorsal furrow to the palpebral lobe, and gently backward to the slight furrow within the posterior margin; to the front they curve down rather rapidly to the frontal border; palpebral ridge narrow and faintly defined; palpebral lobe a little more than one-fourth the length of the cephalon, rising somewhat abruptly from the plane of the fixed cheeks; postero-lateral limb, from the dorsal furrow to its extremity, about the same length as the width of the glabella at its base; it is marked by a shallow, narrow furrow some distance within the posterior margin.

The surface is ornamented by rather large, closely arranged pustules that cover the glabella and fixed cheeks; the pustules are larger on the occipital segment and its extension on the postero-lateral limbs and on the frontal border; larger pustules are also scattered on the back portion of the head near the dorsal furrow. Over the spaces between the larger pustules and on the pustules there is a minute granulation that gives a very highly ornamented surface under a strong lens.

The type and only specimen of the cephalon in the collection has a length of 12 mm., of which the glabella occupies 9 mm.; the width at the outside of the palpebral lobes is 17 mm. and at the ocular ridges 5.5 mm.

The cephalon of this species is much like that of *Damesella blackwelderi* in general form, but it differs in the elevated eye-lobes and the peculiarly ornamented, pustulose surface.

Formation and Locality.—Middle Cambrian: (C 13) Yellow slabby limestone in the middle limestone member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 41 (part of first list of fossils)], on the west slope of hill in angle between two faults just east of the granite mass of the Lién-hua-shan, 6 miles (9.6 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Collected by Bailey Willis.

Damesella blackwelderi Walcott.

Plate 10, Figures 1, 1*a–j*.

Damesella blackwelderi WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 35. (Described and discussed as a new species essentially as below.)

General form ovate, moderately convex; distinctly trilobed, the central axis rather convex and the pleural lobes more or less flattened.

Cephalon transversely semicircular; frontal margin rounded and narrow in young individuals, becoming broader and more flattened with increase in size; it continues around the sides and the postero-lateral angle to unite with the narrowing posterior margin. A postero-lateral spine projects backward and slightly outward from a point on the margin a little in advance of the postero-lateral angle.

Glabella large, truncato-conical in outline, and marked by three pairs of short furrows; the posterior pair of furrows forms a rounded pit near the margin, and continues obliquely outward as a shallow furrow to the central third of the glabella, separating a short, rounded lobe on each side; the middle pair of furrows is short and very lightly impressed; the anterior pair of furrows is indicated by a short, smooth, narrow space at the anterior fourth of the glabella; occipital furrow of medium width, rounded at the bottom, and rather deep; it curves backward slightly at the sides and then arches gently forward at the middle; occipital ring of medium width, curving slightly backward at the ends and forward at the center, rounded on top; dorsal furrow strongly marked all about the glabella and passing posteriorly into a narrow but well-defined furrow within the posterior margin of the postero-lateral limb; the front of the glabella almost overhangs a strong furrow within the frontal border, that separates the frontal border from the fixed cheeks; frontal border or rim strong, rounded, and arching slightly upward in front of the glabella.

Fixed cheeks a little more than one-half the width of the glabella; they slope gently back to the furrow on the postero-lateral limb and rather rapidly downward, in front of the palpebral lobe, to the furrow within the frontal border; a clearly defined, low, rounded palpebral ridge extends opposite the anterior fourth of the glabella to the palpebral lobe, into the rim of which it merges; postero-lateral limb about one and one-third times as long as the width of the glabella at its base, and back of the palpebral lobe about one-third the length of the cephalon; palpebral lobe a little less than one-third the length of the cephalon, elevated at the outer rim, and rather narrow. The facial sutures cut through the rounded frontal margin of the cephalon obliquely and then extend around backward, passing almost directly to the anterior margin of the palpebral lobe; curving around the rather small eye-lobe, they pass obliquely outward and backward, cutting the border of the head a little back of the postero-lateral angle.

Free cheeks roughly subtriangular, with the outer margin bordered by a thickened, rounded rim, which gradually increases in width to the base of the long postero-lateral spine; back of the spine to the facial suture the border narrows rapidly; the body of the cheek rises at a uniform slope to the base of the eye-lobe.

Thorax with a convex axis that narrows gradually from the anterior segment, where the width is 15 mm., to the twelfth segment, where it is 12 mm. One specimen preserves twelve segments, with the pygidium, and, it may be, other segments broken off. The segments are nearly transverse, except at the geniculation on the pleural lobes, where the falcate extremities bend slightly backward; pleural lobes flattened three-fourths of the distance out, where they curve slightly downward to the extremities of the pleuræ; pleural groove occupying nearly the entire width of the pleura, except near the axis, where it narrows toward the front margin; at the outer extremity it fades out where the pleura curves outward and backward. There is some difference in the strength and width of the pleural groove in different specimens; in some it has practically the same width from the axis out to its extremity, while in others it is narrow toward the axis and not quite so broad through the central portions.

Pygidium large, semicircular; axial lobe divided by four well-defined transverse furrows, that arch slightly forward, into four moderately convex rings and a somewhat elevated terminal portion, which has the appearance of a thickened ring with a strong node on each side of the center and a slightly defined furrow on its front slope; the terminal ring slopes rapidly downward to the border; lateral lobes broad, slightly convex, and marked by a narrow anterior ring, which joins the thorax, and four strong, rather broad furrows that separate three rings and a broad, obscure terminal

ring; two obscure ridges run down the posterior slope of the central axis from the two nodes upon the posterior end of the central axis and terminate in spines on the border; each of the rings of the pleural lobe, including the anterior border, terminates in a long, slender spine, that of the anterior border being much longer than the others; this arrangement gives five spines on each side of the axis and two spines back of the axis; the border is rounded and much interrupted by the strong spines extending out from it.

Surface of the crust minutely punctate under a strong lens, and marked by strong pustules, more or less irregularly arranged on the surface, except in the furrows; on the segments of the thorax the pustules are arranged on the front and back margins of the pleuræ and on the higher portions of the rings on the axis; on the pygidium the pustules occur on the elevated rings and somewhat irregularly on the pleural lobes, but not on the spines. On some portions of the surface, under a very strong lens, there appears to be an irregular, inosculating, elevated series of lines or striæ interrupting the surface, leaving minute depressions or punctæ between them.

The portion of the thorax preserving twelve segments has a length of 50 mm., with a width at the anterior end of the axis of 16 mm., and on the pleural lobes of 24 mm.; the cephalon of this specimen has a length of 26 mm. and a width of 64 mm., exclusive of the postero-lateral spines.

The pygidium of this species is not unlike that of *Blackwelderia sinensis* (Bergeron) [p. 121], but it differs in the more depressed axis and in the character of the spines on the border. This conclusion is given after an examination of the figures of M. Bergeron and a comparison of specimens which have been identified from the Ku-shan shale formation, 2.5 miles (4 km.) southwest of Yen-chuang, Sin-t'ai-hién, Shan-tung, China, which appears to be the horizon from which the various species described by M. Bergeron were obtained. From *Olenoides marconi* Whitfield [Walcott, 1891*a*, plate 94, figs. 2, 2*a*–*b*] the pygidium of *Damesella blackwelderi* differs in the same manner as from *Blackwelderia sinensis*. From *Dorypyge slatkowskii* Schmidt [1886, p. 418, plate 12, figs. 11–14] it differs in the character of the cephalon and the general shape of the pygidium and its spinose border. From *Blackwelderia alastor* it differs in the slender axis and spinose border of the pygidium.

This is one of the finest of the trilobites collected by Mr. Blackwelder; and owing to the fact that there are a number of specimens of the head and pygidium, and one specimen preserving the head attached to twelve segments of the thorax, it was possible to separate it from the genera *Dorypyge* and *Olenoides* and to establish a new generic type.

Formation and Locality.—Middle Cambrian: (C12) Gray limestone near the top of the middle limestone member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 41 (part of first list of fossils), and fig. 10 (bed 7), p. 38], 3.25 miles (5.2 km.) southwest of Yen-chuang: (C13) yellow slabby limestone in the middle limestone member of the Kiu-lung group [idem (part of first list of fossils)], on the west slope of hill in angle between two faults, just east of the granite mass of the Lién-hua-shan, 6 miles (9.6 km.) southwest of Yen-chuang; (C14) in talus from the middle limestone member of the Kiu-lung group [idem, p. 37], 2.8 miles (4.5 km.) southwest of Yen-chuang; and (C40), limestone nodules in green shales in the middle limestone member of the Kiu-lung group [idem, pp. 37 and 41 (part of the first list of fossils)], in a gully in bank of river 2 miles (3.2 km.) south of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Collected by Eliot Blackwelder, Bailey Willis, and Li San.

Also from (36f) Fu-chóu series, about 1,000 feet (305 m.) above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general stratigraphic relations], collected in a

low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria, China.

Collected by J. P. Iddings and Li San.

The stratigraphic range given this species is based upon the comparison of specimens that appear to be identical.

Damesella brevicaudata Walcott.

Plate 9, Figure 9.

Damesella brevicaudata Walcott, 1905, Proc. U. S. Nat. Mus., vol. xxix, p. 39. (Described and discussed as a new species essentially as below.)

This species is based upon a pygidium that is transversely semicircular in shape, with a short, strong, convex axis. The axis is marked by two anterior transverse furrows and a very shallow posterior furrow, that divide the axis into an anterior ring, which joined the thorax, two faintly defined rings, and a rounded terminal section; the axis rounds down abruptly at its broad, posterior end, passing into the margin. The dorsal furrow is narrow and clearly defined on each side of the axis.

Pleural lobes flat for a very short distance, and then rounding downward to the border; each lobe is marked by an anterior, deep, narrow furrow within the margin, and four strong furrows terminate within the border; they divide the lobes into four elevated segments that merge into the irregular border; from the border fourteen spines project; the anterior spines appear to be the continuation of the anterior, elevated margin of the pygidium and the first segment; the second, third, fourth, and fifth spines are opposite the furrows between the segments and do not appear to be the direct continuation of the segments, although a low ridge from each segment crosses the margin obliquely to them; two spines project back of the axis, and one on each side opposite the dorsal furrow on the side of the axis.

Surface marked by an irregular row of rather large tubercles on the rings of the axis and anchylosed segments of the pleural lobes; under a very strong lens the surface appears to be slightly roughened or minutely punctate.

Length of pygidium, 7 mm.; width in front of border, exclusive of spines, 16 mm.; width of axis at anterior margin, 5 mm.

The pygidium of this species is characterized by its short, wide, convex central axis, relatively narrow pleural lobes, and very strong, spinose border. It differs from *Dorypyge richthofeni* Dames [p. 108] in its short, broad axis and the character of the pleural lobes and spinose border.

Formation and Locality.—Middle Cambrian: (C19) Uppermost layers of the Ch'ang-hia limestone [Blackwelder, 1907*a*, p. 33 (part of the last list of fossils)], at Ch'ang-hia, Shan-tung, China.

Collected by Li San.

Damesella sp. undt. (*c*).

Plate 9, Figure 12.

Only the matrix of a pygidium is known of this form. This has a strong median lobe divided by four narrow transverse furrows into four segments and a broad terminal section that touches the border. The axial segments continue out on the pleural lobes to where they merge into the border.

The pleural segments do not show a furrow and in this respect are similar to the pleural segments of the pygidium of *Damesella blackwelderi* [plate 10, figs. 1*e–j*].

The tuberculate surface is much like that of *D. blackwelderi*, and I would identify the pygidium with the latter species except that it occurs several hundred feet lower in the section studied by Prof. J. P. Iddings.

Formation and Locality.—Middle Cambrian: (35 o) Fu-chóu series, shales about 130 feet (40 m.) above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general section giving stratigraphic relations]; collected in drainage cuts a short distance back from the bluff [see 35 n] forming the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria, China.

Collected by J. P. Iddings and Li San.

Genus DREPANURA Bergeron.

Drepanura BERGERON, 1899, Bull. Soc. géol. de France, 3d ser., vol. XXVII, p. 509. (Describes and discusses genus.)

Drepanura Bergeron, MONKE, 1903, Jahrb. königl. Preuss. Geol. Landesanstalt und Bergakademie, vol. XXIII, pt. 1, p. 124. (Discusses genus under the species *D. premesnili* Bergeron.)

Both M. Bergeron and Doctor Monke united the description of the genus and the type species. Nothing has been added to our knowledge since Doctor Monke wrote his very full description of *D. premesnili*, the type of the genus. Doctor Monke described a second species, *D. ketteleri*, which differs in the cranidium from that of *D. premesnili* in having the eye-lobes further back and in details of the glabella and free cheeks, also of the pygidium. [See plate 10, figs. 2, 2*b*, 3, 3*a*.]

Genotype.—*Drepanura premesnili* Bergeron.

Drepanura ketteleri Monke.

Plate 10, Figures 3, 3*a–c*.

Drepanura ketteleri MONKE, 1903, Jahrb. königl. Preuss. Geol. Landesanstalt und Bergakademie, vol XXIII, pt. 1, p. 132, plate 6, figs. 1–14; plate 9, No. 5. (Described as a new species.)

This species differs from *Drepanura premesnili* Bergeron by its strongly granulated test, more convex glabella, the position of the eye-lobes, and many minor details of the cranidium. The pygidium is of the same type as that of *D. premesnili*, as may be seen by comparing figures 3*a* and 3*c* with 2*b* and 2*c*, plate 10. Doctor Monke has given a very elaborate description of all known parts and made extended comparisons with *D. premesnili*.

Formation and Locality.—Middle Cambrian: (C6) Thin, platy limestone in the upper shale member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 41 (second list of fossils), and fig. 10 (bed 12), p. 38], 2.5 miles (4 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung; also (C55), just below the Ch'au-mi-tién limestone in Ku-shan shales [idem, p. 43], in isolated hills at an elevation of 380 feet (114 m.) above the Wön-ho, 12 miles (19 km.) south 80° east of Tsi-nan, Shantung, China.

Collected by Bailey Willis and Eliot Blackwelder.

Drepanura premesnili Bergeron.

Plate 10, Figures 2, 2*a–d*; Plate 11, Figures 1–5.

Drepanura premesnili BERGERON, 1899, Bull. Soc. géol. de France, 3d ser., vol. XXVII, p. 509, plate 13 fig. 8. (Species described and discussed.)

Drepanura premesnili Bergeron, MONKE, 1903, Jahrb. königl. Preuss. Geol. Landesanstalt und Bergakademie, vol. XXIII, pt. 1, p. 124, plate 5, figs. 5–19; plate 9, No. 4. (Describes and discusses species very fully.)

M. Bergeron founded this genus and species on the pygidia occurring on a thin slab of limestone. Subsequently Doctor Monke described in detail and illustrated the cephalon, thoracic segments, and pygidia. Among the collections of the Carnegie Institution of Washington Expedition, fine illustrations of the cranidium, free cheeks, and pygidia occur, also fragments of the thoracic segments, but nothing is added except that the true stratigraphic position of the genus and species has

been determined. Doctor Monke compares *Drepanura* with *Teinistion* and the Scandinavian genera *Acerocare* and *Peltura*.

Formation and Locality.—Middle Cambrian: (C6) Thin, platy limestone in the upper shale member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 41 (second list of fossils), and fig. 10 (bed 12), p. 38], 2.5 miles (4 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung; and (C55), just below the Ch'au-mi-tién limestone in the Ku-shan shales [idem, p. 43], in isolated hills at an elevation of 380 feet (114 m.) above the Wön-ho, 12 miles (19 km.) south 80° east of Tsi-nan, Shan-tung, China.

Collected by Bailey Willis and Eliot Blackwelder.

Also from (36f), Fu-chóu series; about 1,000 feet (305 m.) above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general stratigraphic relations], collected in a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria, China.

Collected by J. P. Iddings and Li San.

Genus PTYCHOPARIA Corda.

Ptychoparia CORDA, 1847, Prodrom einer Monographie der böhmischen Triboliten, p. 141. (Proposes *Ptychoparia* for generic group of trilobites represented by *Conocephalites striatus* Emmrich and gives diagnosis of genus.)

Ptychoparia Corda, WALCOTT, 1884, Bull. U. S. Geol. Survey No. 10, On the Cambrian Faunas of North America, pp. 34–36. (Compares and discusses genus.)

Ptychoparia Corda, LORENZ, 1906, Zeitschr. deutsch. geol. Gesellsch., vol. LVIII, pt. 2, p. 57. (Quotes Corda's diagnosis and adds "dense shell structure" as a generic character.)

Many authors have referred to the genus *Ptychoparia*. I will not enter into a discussion of it at this time, as I am planning to give the genus more extended consideration in connection with the description of a number of new species from North America.

In this memoir the genus is restricted to species having the characteristics of *Ptychoparia striata* Emmrich. One character should be noted. The increase in the length of the palpebral lobe from the short lobe of *P. striata* [plate 12, fig. 4] to the proportionately longer lobe of *P. kingi* [fig. 6] is marked. In *P. striata* the cephalon is four and a half times as long as the palpebral lobe, and in *P. kingi* it is three times as long. This elongation of the palpebral lobe is continued in *Conocephalites emmrichi* Barrande [plate 13, fig. 7] and other species grouped under *Conokephalina*.

In Walcott, 1905*b* [Proc. U. S. Nat. Mus., vol. XXIX, p. 81], an undetermined species of *Ptychoparia* was described, based on a single specimen of the central portion of a cephalon, from the Middle Cambrian, Locality C58, upper portion of the Ch'ang-hia formation, near the middle of the Ch'ang-hia oolitic limestone, 2 miles (3.2 km.) south-southeast of Kao-kia-p'u, Shan-tung. The specimen upon which this species was determined was lost or misplaced before the final study of the fauna.

There is also another undetermined species of *Ptychoparia*, from Locality C48, which shows only the narrow portions of the cranidium and part of a fixed cheek.

Formation and Locality.—Middle Cambrian: (C48) Near the top of the cliffy oolitic limestone in the Ch'ang-hia limestone [Blackwelder, 1907*a*, p. 32 (part of last list of fossils)], at Ch'au-mi-tién, Shan-tung.

Ptychoparia aclis Walcott.

Plate 12, Figures 8, 8*a*.

Ptychoparia aclis WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 75. (Described as a new species as below.)

Only the slightly convex central portions of the cephalon of this species are known. The species is distinguished by the breadth of the glabella in front, and

three pairs of short, well-defined furrows that divide the sides of the glabella into four subequal lobes; an occipital spine and a narrow, rounded frontal rim, cut around in front nearly to the median line by the facial sutures. Palpebral ridge well defined. Surface unknown.

Formation and Locality.—Lower Cambrian: (C20) Central part of the Man-t'o shale formation [Blackwelder, 1907*a*, p. 26 (last list of fossils), and fig. 6 (bed 14), p. 25], on the west side of an isolated butte 1 mile (1.6 km.) south of Ch'ang-hia; also (C17), ferruginous limestone nodules in the brown sandy shales at the top of the Man-t'o shale [idem, p. 27 (list of fossils at top of page), and fig. 6 (bed 15), p. 25], and (C31) gray crystalline limestone in the central portion of the Man-t'o shales [idem, p. 26 (first list of fossils), and fig. 6 (bed 12), p. 25], both at Ch'ang-hia, Shan-tung, China.

Collected by Eliot Blackwelder.

Ptychoparia granosa Walcott.

Plate 12, Figure 7.

Ptychoparia granulosa WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 78. (Species described as below. This species is believed to be congeneric with Hall and Whitefield's species; since the name *granulosa* is therefore preoccupied for *Ptychoparia, granosa* is proposed.)

Not *Crepicephalus* (*Loganellus*) *granulosus* HALL and WHITEFIELD, 1877, Geol. Expl. Fortieth Parallel, vol. IV, p. 214, plate 2, figs. 2 and 3.

Ptychoparia granosa WALCOTT, 1911, Smithsonian Misc. Coll., vol. 57, No. 4, pp. 77–78, plate 14, fig. 8. (Species described and discussed essentially as below.)

The gently convex central portions of the cephalon, exclusive of the free cheeks, are all that is known of this species. These indicate a rather broad, semicircular cephalon, with small free cheeks, wide fixed cheeks, narrow, short, convex glabella, and narrow, flattened frontal rim; glabella marked by three pairs of faintly impressed but clear glabellar furrows; frontal space between the glabella and rim broader than the frontal rim and slightly convex; palpebral ridge narrow, clearly defined, and merging into a rather small eye-lobe.

Surface slightly granulose.

Formation and Locality.—Lower Cambrian: (C17) Ferruginous limestone nodules in the brown sandy shales at the top of the Man-t'o shale [Blackwelder, 1907*a*, p. 27 (list of fossils at top of page), and fig. 6 (bed 15), p. 25], at Ch'ang-hia, Shan-tung, China.

Collected by Eliot Blackwelder.

Ptychoparia impar Walcott.

Plate 12, Figures 9, 9*a*.

Ptychoparia impar WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 78. (Characterized as a new species.)

This species is represented by many fine specimens of the rather convex central portions of the head. The form of the parts preserved is not unlike that of *Ptychoparia aclis* [p. 130]. They differ in being stronger and more convex, in the absence of an occipital spine, and the presence of rather faint glabellar furrows. Palpebral ridge rounded and rather strong.

Surface finely punctate.

Formation and locality.—Lower Cambrian: (C17) Ferruginous limestone nodules in the brown sandy shales at the top of the Man-t'o shale]Blackwelder, 1907*a*, p. 27 (list of fossils at top of page), and fig. 6 (bed 15), p. 25], at Ch'ang-hia, Shantung, China.

Collected by Eliot Blackwelder.

Ptychoparia impar var. ? Walcott.

Plate 12, Figure 10.

Ptychoparia impar var. ? WALCOTT, 1905, Proc. U.S. Nat. Mus., vol. XXIX, p. 79. (Variety characterized as below.)

This variety differs from the type of the species in having more distinctly defined glabellar furrows, slightly narrower frontal rim, and more rounded frontal margin to the glabella. There are several specimens of the cephalon from one locality which appear to vary among themselves as much as some of them vary from *P. impar* [p. 131]. The latter, and the forms referred to the variety, come from the upper portion of the Man-t'o formation.

Formation and Locality.—Middle Cambrian: (C8) Brown sandstone and limestone nodules in brown micaceous shales near the top of the Man-t'o formation [Blackwelder, 1907*a*, fig. 8*a* (bed 27), p. 29], 3.4 miles (5.4 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Collected by Eliot Blackwelder.

Ptychoparia kochibei Walcott.

Plate 12, Figures 5, 5*a–e*.

Ptychoparia kochibei WALCOTT, 1911, Smithsonian Misc. Coll., vol. 57, No. 4, pp. 78–79, plate 14, figs. 10 and 10*a*. (Described and discussed as a new species essentially as below.)

The cephalon of *P. kochibei*, in outline, wide fixed cheeks, broad frontal limb, and broadly rounded front margin of the glabella, is similar to the cephalon of *Ptychoparia granosa* Walcott [plate 12, fig. 7]. It differs in having a more pronounced swelling of the frontal limb in front of the glabella, more tumid fixed cheeks, and in surface characters. The surface of *P. granosa* is thickly studded with minute tubercles, while that of *P. kochibei* is smooth or possibly finely punctate; its frontal limb is also marked by fine, irregular, sometimes inosculating, rounded ridges that extend from in front of the glabella and palpebral ridges to the groove within the flattened frontal rim [fig. 5*b*].

The thorax has fourteen transverse segments with a narrow axial lobe and wide pleural lobes. The pleural furrow starts on the inner front side of the pleural lobe of each segment and, widening nearly to the width of the segment, begins to narrow at the point of geniculation and terminates near the posterior margin at the somewhat abrupt falcate termination of the pleura.

Pygidium small; the axial lobe is crossed by two furrows that serve to outline two transverse rings and a terminal section; two anchylosed segments are outlined on the pleural lobes on each side of the axial lobe by furrows that curve gently backward toward the faintly defined border.

Surface finely punctate or slightly roughened by minute depressions.

This is the only Chinese species of *Ptychoparia* of which we have the entire dorsal shield; all the other species are represented by the separated parts. In outline the dorsal shield is not unlike that of *Ptychoparia kingi* (Meek) [see Walcott, 1886, p. 193], and it may be considered as the Chinese representative of that species. For comparison a photograph of a specimen of *P. kingi* [fig. 6, plate 12] is given on the plate with the figures of *P. kochibei*.

The specific name is given in honor of the former Director of the Geological Survey of Japan, Doctor Kochibe.

Formation and Locality.—Middle Cambrian: (35n, 35r, and 36e), Fu-chóu series, limestones and shales interbedded with limestones near the base of the series just

above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general section giving stratigraphic relations], collected in a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria, China.

Collected by J. P. Iddings and Li San.

Ptychoparia ligea Walcott.

Plate 12, Figure 11.

Ptychoparia ligea WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 79. (Described as a new species as below.)

Cephalon, exclusive of free cheeks, subquadrilateral in outline, moderately convex. Glabella almost of the same width from the posterior margin to the rounded front; three pairs of furrows are faintly but clearly indicated; occipital ring strong; occipital furrow shallow but extended out on the lateral limbs as a strong furrow.

Fixed cheeks nearly as wide as the glabella; palpebral lobes short and small; palpebral ridges narrow and strongly defined; frontal limb slightly convex to where it merges into the broad, shallow furrow that extends nearly out to the front margin; postero-lateral limbs rather long.

Surface slightly roughened by minute, irregular, raised lines than can only be seen with a strong lens.

Formation and Locality.—Lower Cambrian: (C31) Gray crystalline limestone in the central portion of the Man-t'o shales [Blackwelder, 1907*a*, p. 26 (first list of fossils), and fig. 6 (bed 12), p. 25], at Ch'ang-hia, Shan-tung, China.

Collected by Eliot Blackwelder.

Ptychoparia lilia Walcott.

Plate 12, Figures 12, 12*a*.

Ptychoparia lilia WALCOTT, 1906, Proc. U. S. Nat. Mus., vol. XXX, p. 588. (Characterized as a new species as below.)

This species is represented by a single fragment of a cephalon, preserving the glabella, the left fixed cheek, and the frontal limb and rim. It is characterized by the convex glabella, marked by three short, very slightly indicated pairs of glabellar furrows, and the strong, rounded frontal rim separated from the glabella by a very short frontal limb.

The fixed cheeks are moderately convex and marked by faint, obliquely transverse palpebral ridges, palpebral lobes unknown; frontal limb narrow, slightly convex; frontal rim strong, rounded thickened in front, and separated from the frontal limb by a shallow, narrow furrow.

Surface formed by a network of fine, irregular, inosculating, very slightly elevated lines. This surface, when partly worn, has a punctate appearance owing to the shallow places between the lines. The type and only specimen of the cephalon has a length of 5 mm.

The associated free cheeks have a strong, rather broad border that is continued posteriorly as a strong and rather long spine.

Formation and Locality.—Middle Cambrian: (C75) Limestone near the base of the Ki-chóu formation [Willis and Blackwelder, 1907, p. 143], 4.5 miles (7.2 km.) south of Wu-t'ai-hién, Shan-si, China.

Collected by Eliot Blackwelder.

Ptychoparia ? tolus Walcott.

Plate 12, Figure 13.

Ptychoparia tolus WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 82. (Described as in first paragraph below.)

Of this species only a single, fragmentary cephalon in known; this is much like the corresponding parts of the cephalon of *Anomocarella thraso*, but it differs (*a*) in being less convex, (*b*) in having a more coarsely granulated surface, (*c*) stronger posterior glabellar furrows, (*d*) broader fixed cheeks, and (*e*) more broadly rounded front to the glabella. The length of the cephalon is 10 mm.; of the glabella, 7 mm.; width of the cephalon, including palpebral lobes but not fixed cheeks, 12 mm.

The strong granulation on the surface indicates that *P. ? tolus* will be found to belong to some other genus than *Ptychoparia* when the entire dorsal shield is known.

Formation and Locality.—Middle Cambrian: (C52) In the lower part of the limestone member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 39 (second list of fossils), and fig. 7 (bed 22), p. 27], near base of cliffs in mountain 1,000 feet (305 m.) high, 3 miles (4.8 km.) north-northeast of Sin-t'ai-hién, Shan-tung, China.

Collected by Eliot Blackwelder.

Ptychoparia typus (Dames).

Plate 12, Figures 14, 14*a–c*.

Conocephalites typus DAMES, 1883, China, Richthofen, vol. IV, p. 11, plate 2, figs. 11, 12. (Described and figured.)

Of this species only the central portions of the cephalon and pygidium are known. These were described and illustrated by Doctor Dames and in this paper examples from the shale are figured.

Formation and Locality.—Middle Cambrian: (35o) Fu-chóu series, shales about 130 feet (40 m.) above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general section giving stratigraphic relations]; collected in drainage cuts a short distance back from the bluff [see 35n] forming the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria, China.

Collected by J. P. Iddings and Li San.

EMMRICHELLA Walcott, subgenus of PTYCHOPARIA.

Emmrichella WALCOTT, 1911, Smithsonian Misc. Coll., vol. 57, No. 4, p. 79. (Described and discussed as a new genus essentially as below.)

This subgenus differs from *Ptychoparia* in its smooth glabella and larger palpebral lobe; from *Liostracus* in having an arched or nearly flat frontal limb and rim and more convex cranidium; from *Conokephalina* in its smoother glabella and wider fixed cheeks; and from *Anomocare* in its smoother glabella, usual absence of distinct palpebral ridge, and proportionately shorter eye-lobes and glabella.

Genotype.—Ptychoparia theano Walcott.[1]

This subgenus is characterized by a nearly smooth surface on the glabella and fixed cheeks, rather large palpebral lobes, and narrow postero-lateral limbs. Unfortunately, no entire specimens of the cephalon and thorax are known, and the pygidia referred to it may or may not belong to the species to which they are tentatively assigned. Only when a thorough study is made of all the material within the Conokephalinæ will it be possible to make even a fairly adequate grouping of the species.

[1]Walcott, 1905*b*, Proc. U. S. Nat. Mus., vol. 29, p. 82; Idem, 1911, Smithsonian Misc. Coll., vol. 57, No. 4, plate 14, figs. 9 and 9*a*.

Of the species from China of this subgenus, *P. (E.) theano* (Walcott) [plate 13, fig. 2], *P. (E.) bromus* (Walcott) [fig. 3], and *P. (E.) eriopia* (Walcott) [fig. 4] have the posterior elongate palpebral lobe. In *P. (E.) mantoensis* (Walcott) [fig. 1] and *P. (E.) constricta* (Walcott) [fig. 5] the palpebral lobe is much like that of *Ptychoparia* in its position.

Stratigraphic Range.—*Ptychoparia (Emmrichella) mantoensis* and *P. (E.) constricta* occur at the summit of the Lower Cambrian; *P. (E.) eriopia* and *P. (E.) theano* at the base of the Ch'ang-hia formation of the Middle Cambrian; and *P. (E.) bromus* at about the same horizon in the Kiu-lung formation.

Ptychoparia (Emmrichella) bromus (Walcott).

Plate 13, Figure 3.

Ptychoparia ? bromus WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 76. (Described as a new species essentially as below.)

This species is represented by the central portions of the cephalon, exclusive of the free cheeks. Glabella moderately convex, truncato-conical, rounded in front, and apparently without furrows; occipital furrow transverse and clearly defined; occipital ring strong and moderately convex; dorsal furrow broad and shallow.

Fixed cheeks nearly as wide as the glabella opposite the palpebral lobe; they rise slightly from the dorsal furrow to the palpebral lobe, and slope gently backward to the postero-lateral limb and forward to the frontal limb; palpebral lobe narrow, about one-third the length of the cephalon; palpebral ridge rounded and faintly defined; frontal limb of medium width, slightly convex, and sloping gently down to a rounded furrow that separates it from the flattened frontal rim, which is about one-half as wide as the frontal limb.

The surface is slightly roughened by minute granulations, as seen with the aid of a strong lens.

The largest specimen of the cephalon in the collection has a length of 7 mm.

This species is characterized by the rounded, smooth appearance of the glabella, fixed cheeks, dorsal furrow, and frontal limb.

Formation and Locality.—Middle Cambrian: (C6) Thin, platy limestone in the upper shale member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 41 (second list of fossils), and fig. 10 (bed 12), p. 38], 2.5 miles (4 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Collected by Eliot Blackwelder.

Ptychoparia (Emmrichella) constricta (Walcott).

Plate 13, Figures 5, 5*a*.

Ptychoparia constricta WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 77. (Described as a new species.)

The convex central portions of the cephalon, exclusive of the free cheeks, are subquadrilateral in outline. Glabella subcylindrical, narrowing slightly toward the front, with only faint indications of glabellar furrows; occipital furrow narrow, clearly defined, but shallow; occipital ring strong, narrow at the sides and broad at the center.

Fixed cheeks about as broad as the glabella; palpebral ridges strong and merging into the rather long palpebral lobes; frontal limb well defined by the palpebral ridges and narrow, slightly flattened frontal rim.

Surface slightly roughened by minute, irregular, raised lines.

Formation and Locality.—Lower Cambrian: (C3) Lower part of the Man-t'o shale formation [Blackwelder, 1907*a*, p. 28 (list of fossils at bottom of page), and

fig. 8*a* (bed 20), p. 28], on the southeast slope of Hu-lu-shan, 2.5 miles (4 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Collected by Eliot Blackwelder.

Ptychoparia (Emmrichella) eriopia (Walcott).

Plate 13, Figures 4, 4*a*.

Anomocare eriopia WALCOTT, 1906, Proc. U. S. Nat. Mus., vol. XXX, p. 582. (Discussed as a species of *Anomocare*.)

This species was first placed under the genus *Anomocare*, but with the grouping of species under a subgenus of *Ptychoparia*, that have a cranidium somewhat similar to that of *P.* (*Emmrichella*) *theano* [plate 13, fig. 2], the species *eriopia* appears to belong with them. In form of the frontal limb and rim and the posterior position of the palpebral lobes it is close to *P.* (*E.*) *theano* [fig. 2]. Its glabella is more like that of *P.* (*E.*) *mantoensis* [fig. 1].

Formation and Locality.—Middle Cambrian: (C23) Upper part of thin-bedded gray oolitic limestone at the base of the Ch'ang-hia formation [Blackwelder, 1907*a*, p. 32 (second list of fossils), and fig. 6 (bed 20), p. 25], 50 feet (15 m.) below the base of the cliffs 1 mile (1.6 km.) east-southeast of Ch'ang-hia, Shan-tung, China.

Collected by Eliot Blackwelder.

Ptychoparia (Emmrichella) mantoensis (Walcott).

Plate 13, Figures 1, 1*a–c*.

Ptychoparia mantoensis WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 79. (Described as a new species as below.)

Only the central portions of the moderately convex cephalon of this species are definitely known. It is characterized by the broad frontal space and flat frontal rim. The sides of the glabella converge slightly toward the front margin, which is broadly rounded; glabellar furrows indicated by three very faint depressions on each side; occipital furrow relatively shallow and rounded.

Fixed cheeks rather broad; the eye-lobe occupies the central third of the distance from the posterior margin to the anterior flattened rim; palpebral ridges not strongly marked. The outlines of the free cheeks and the course of the facial sutures are shown in the outline figures.

Surface slightly roughened by almost microscopic, irregular, raised lines.

An associated free cheek has a long, slender postero-lateral spine.

Formation and Locality.—Lower Cambrian: (C20) Central part of the Man-t'o shale formation [Blackwelder, 1907*a*, p. 26 (last list of fossils), and fig. 6 (bed 14), p. 25], on the west side of an isolated butte 1 mile (1.6 km.) south of Ch'ang-hia, Shan-tung, and (C31) gray crystalline limestone in the central portion of the Man-t'o shales [idem (first list of fossils), and fig. 6 (bed 12), p. 25], at Ch'ang-hia, Shan-tung, China.

Collected by Eliot Blackwelder.

Ptychoparia (Emmrichella) theano (Walcott).

Plate 13, Figure 2.

Ptychoparia theano WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 82. (Described and discussed as below.)

Cephalon small, moderately convex. Glabella subquadrilateral, moderately convex, a little narrower in front than at the base, and without glabellar furrows; occipital ring practically a continuation of the glabella, as the shallow occipital furrow barely indicates it; dorsal furrow narrow at the sides of the glabella, and very obscure in front of it.

Fixed cheeks a little wider than the glabella and nearly flat from the dorsal furrow to the palpebral lobes; palpebral lobes large, situated opposite the central portion of the glabella; palpebral ridges obscure, low and broad, and very clearly defining the lateral portions of the fixed cheeks from the frontal limbs; frontal limb narrow in front of the glabella, sloping downward to the broad, shallow furrow that merges into the broad, almost flat frontal rim; postero-lateral limbs short; a narrow, sharp furrow extends along their posterior margin from the glabella to the facial suture, just within the posterior lateral margin.

Surface minutely granular under a very strong lens.

The largest cephalon has a length of 5 mm.

This species is distinguished by the broad, flat fixed cheeks, convex, smooth glabella, large palpebral lobes, and nearly flat frontal margin.

Formation and Locality.—Middle Cambrian: (C23) Upper part of thin-bedded gray oolitic limestone at the base of the Ch'ang-hia formation [Blackwelder, 1907*a*, p. 32 (second list of fossils), and fig. 6 (bed 20), p. 25], 50 feet (15 m.) below the base of the cliffs 1 mile (1.6 km.) east-southeast of Ch'ang-hia, Shan-tung, China.

Collected by Eliot Blackwelder.

Genus LIOSTRACUS Angelin.

Liostracus ANGELIN, 1854 (edition 1878), Pal. Scandinavica, pt. 1, p. 27. (Described as a new genus.)

Genotype.—*Liostracus aculeatus* Angelin.

The cephalon of *Liostracus aculeatus* has a smooth, convex glabella, a narrow, flat, or slightly convex frontal limb, with a nearly flat or slightly convex margin that in *L. aculeatus* is turned upward in relation to the plane of the margin of the cephalon. I find some variation in this respect among a half dozen specimens from Borgholm and Andrarum in the collections of the United States National Museum. All of the specimens have small eyes, well-marked palpebral lobes and ridges, and a strong occipital spine. Surface with many fine pits that give the impression that the test may be porous, but of this there is not any proof, as the pits may be only a surface character. I am inclined to the view that much of the so-called porous surface is formed by the pits between the fine, low ridges that form a network on the outer surface of the test.

As far as known to me, no specimens of the entire dorsal shield of *L. aculeatus* have been found.

Among the species from China there do not appear to be any that come within the restricted limits of *Liostracus*. *Ptychoparia* (*Emmrichella*) *mantoensis* [plate 13, fig. 1] and *P.* (*E.*) *constricta* [plate 13, fig. 5] approach most nearly, but they differ in having a convex, instead of concave, frontal limb and in the absence of an occipital spine. For convenience of comparison I have illustrated a specimen of the cranidium of *Liostracus aculeatus* Angelin from Borgholm [plate 13, figs. 6, 6*a*–*b*].

Genus CONOKEPHALINA Brögger.

Conokephalina BRÖGGER, 1886, Geol. Fören. i Stockholm Förhandl., No. 101, vol. VIII, pt. 3, p. 206. (Names subgenus to include *Conocephalites ornatus* Brögger, 1877, *Dikelocephalus osceola* Hall, but does not define subgenus.)

Conocephalina Brögger, GRÖNWALL, 1902, Danmarks Geol. Unders., Raekke 2, No. 13, p. 150. (Uses generic name, but does not define genus.)

Conocephalina Brögger, LORENZ, 1906, Zeitschr. deutsch. geol. Gesellsch., vol. LVIII, pt. II, p. 64. (Revives genus *Conocephalites*, places *Conokephalina* Brögger in it, and takes a new type for *Conokephalina*, in *Conocephalites emmrichi* Barrande.)

Genotype.—*Conocephalites ornatus* Brögger, 1877, Nyt Mag. Naturvidenskaberne, vol. XXIV, p. 37, plate 3, figure 5.

This genus, as pointed out by Brögger, occupies an intermediate position between forms referred to *Dikelocephalus* and *Ptychoparia* (*Conocephalites* as used by Brögger). He refers to *Conokephalina*, *Dikelocephalus osceola* Hall, *D. misa* Hall, and *D. spiniger* Hall. I now refer *D. misa* to *Conokephalina*, but *D. osceola* and *D. spiniger* will be placed under genera that will soon be described and illustrated in connection with a paper on the genus *Dikelocephalus* and allied genera.

Conocephalites emmrichi Barrande appears to belong to this genus and as entire specimens of the dorsal shield are known it is illustrated on plate 13, figures 7, 7*a*.

Among the fragmentary forms from China, six appear to come within the limits of the genus, as far as may be determined by having only the cranidium for comparison.

Conokephalina is characterized by its elongate palpebral lobes, narrow free cheeks, and elongate glabella narrowing more or less slightly toward the broadly rounded front.

The Chinese species referred to it are: *C. belus* (Walcott), *C. ? dryope* (Walcott), *C. maia* (Walcott), *C. vesta* (Walcott), and *C.* sp. undt. (Walcott).

Conokephalina belus (Walcott).

Plate 13, Figures 12, 12*a*.

Solenopleura belus WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 90. (Described as a new species essentially as below.)

This species is represented by a fragment of the cephalon that includes the glabella and fixed cheeks. The glabella is moderately convex and narrows slightly toward the rather broadly rounded front; the surface is marked by a pair of short, oblique posterior furrows and one anterior pair at about the anterior third; occipital furrow narrow, distinct, arching forward at the center, and considerably deeper toward the end; occipital ring clearly defined; of moderate width, and slightly convex; dorsal furrow narrow and clearly defined.

Fixed cheeks narrow, scarcely more than a ridge between the dorsal furrow and the palpebral lobe; posteriorly they slope downward to a long postero-lateral limb, and anteriorly drop rather rapidly to the frontal limb; palpebral lobe a little more than one-third the length of the glabella in front, deeply grooved along its center by a furrow parallel to the elevated posterior margin; frontal limb short and slightly convex in front of the glabella; it passes into a shallow furrow within a slightly rounded frontal rim; the latter is broken away except at the ends.

Surface marked by numerous, scattered, rather small pustules.

Length of cephalon, 6 mm., with a width at the palpebral lobes of 5 mm.

This species at first suggests *Solenopleura agno* [p. 167], but differs from that and other species from China in its very narrow fixed cheeks and relatively large palpebral lobes.

Formation and Locality.—Upper Cambrian: (C56) Lower part of Ch'au-mi-tién limestone, 25 feet (7.5 m.) below the top of Pagoda Hill [Blackwelder, 1907*a*, p. 42 (part of last list of fossils)], 1 mile (1.6 km.) west of Tsi-nan, Shan-tung, China.

Collected by Eliot Blackwelder and Li San.

Conokephalina dryope (Walcott).

Plate 13, Figures 11, 11*a–b*.

Ptychoparia dryope WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 78. (Species discussed essentially as below.)

The cephalon representing this species is somewhat of the same type as that of *Incuyia titiana* [plate 14, fig. 9] from the base of the Ch'ang-hia limestone.

It differs from it in having a more elongate glabella, which is more transverse in front. It is also not probable that species of this character would range through 2,500 feet (762 m.) of limestone. It is often the case that cephala that appear to have the general features of *Ptychoparia* are found to belong to other genera when the thorax and pygidium are known. This species is associated with *Ptychaspis ceto*, *Illænurus dictys*, *Menocephalus ? depressus*, and *Cyrtoceras cambria*.

Formation and Locality.—Upper Cambrian: (C56) Lower part of Ch'au-mi-tién limestone, 25 feet (7.5 m.) below the top of Pagoda Hill [Blackwelder, 1907*a*, p. 42 (part of last list of fossils)], 1 mile (1.6 km.) west of Tsi-nan, Shan-tung, China.

Collected by Eliot Blackwelder and Li San.

Conokephalina maia (Walcott).

Plate 13, Figure 13.

Ptychoparia (?) maia WALCOTT, 1906, Proc. U. S. Nat. Mus., vol. XXX, p. 592. (Discussion of species essentially as below.)

This species is represented by one fairly good specimen of the central portions of the cephalon, to which the description of *Ptychoparia (Emmrichella) bromus* [p. 135] applies, with the exception that the latter has broader fixed cheeks and a flatter frontal rim. *Conokephalina maia* also has short, strong palpebral ridges that are not present in *P. (E.) bromus*.

The type specimen of the cephalon has a length of 4.25 mm.

Formation and Locality.—Middle Cambrian: (C70) Oolitic limestone about 30 feet (9 m.) above the base of the Ki-chóu limestone [Willis and Blackwelder, 1907, p. 144 (last list of fossils)], 4 miles (6.4 km.) south-southwest of Tung-yü, Shan-si, China.

Collected by Eliot Blackwelder.

Conokephalina vesta (Walcott).

Plate 13, Figures 9, 9*a–c*.

Ptychoparia vesta WALCOTT, 1906, Proc. U. S. Nat. Mus., vol. XXX, p. 590. (Species described and discussed essentially as below.)

Of this species the central portions of the cephalon are known, also associated free cheeks and pygidia. The parts of the cephalon preserved show it to have been moderately convex, and semicircular in outline. Glabella convex, not very prominent, broadly truncato-conical in outline; antero-lateral angles rounded, front gently curved; between the base and front the sides are slightly incurved at a point about two-thirds the distance from the base of the front; three pairs of glabellar furrows that extend about one-half the distance from the sides toward the center are faintly impressed; occipital furrow narrow, shallow, and transverse; occipital ring narrow at the sides, widening toward the center where the surface is on the plane of the glabella; dorsal furrow narrow and clearly defined at the sides, and shallow in front of the glabella.

Fixed cheeks a little more than one-half the width of the glabella, nearly flat opposite the palpebral lobes, curving gently downward posteriorly to the posterior furrow, and rather abruptly downward to merge into the frontal limb; palpebral lobes a little less than one-half the length of the cephalon, narrow, and separated from the fixed cheeks by rather strong, curved furrows; palpebral ridge low, rather strong, and extending obliquely forward from the anterior edge of the palpebral lobe to the side of the glabella, just back of its antero-lateral angle; frontal limb short, gently convex, and sloping down from the front of the glabella to the rounded furrow formed by its merging with the frontal rim; frontal rim nearly flat and rising at a low angle from the furrow.

Surface smooth to the unaided eye, finely punctate under a strong lens. The largest cephalon referred to this species has a length of 9 mm., and the specimen selected as the type a length of 4 mm., with a width at the outer edge of the palpebral lobes of 6 mm.

The associated free cheek has the same type of nearly flat rim as the rim in front of the glabella; this is extended at the postero-lateral angle into a moderately strong, sharp spine; the body of the cheek rises to the base of the eye-lobe with very little convexity; it is separated from the lateral and posterior borders by a shallow furrow; the surface is marked by irregular lines radiating from the base of the eye-lobe toward the furrow within the outer margin.

The associated pygidium has a planulate border that merges into the slope of the pleural lobes; axis convex, about three-fourths the length of the pygidium, and marked by three shallow, transverse furrows that are continued across the pleural lobes out onto the planulate margin.

The general form of the cephalon of this species is much like that of *Ptychoparia impar* [p. 131]. It differs in having a flatter frontal rim, less convex frontal limb, stronger glabellar furrows, and larger palpebral lobes. From *Anomocare megalurus* Dames [p. 192] it differs by having a more subquadrangular glabella and larger palpebral lobes.

Formation and Locality.—Middle Cambrian: (C69) Limestone in shales about 65 feet (19.5 m.) above the base of the Ki-chóu limestone [Willis and Blackwelder, 1907, p. 145 (first list of fossils)], 4 miles (6.4 km.) east of Fang-lan-chön, Shan-si, China.

Collected by Eliot Blackwelder.

Conokephalina sp. undt. (Walcott).

Plate 13, Figure 10.

Ptychoparia sp. undt. WALCOTT, 1906, Proc. U. S. Nat. Mus., vol. xxx, p. 591. (Species discussed essentially as below.)

This form is represented by a minute cephalon 1.25 mm. in length. It has an elongate glabella of the type of *Ptychoparia (Emmrichella) theano* [p. 136] but its palpebral lobes are longer than in that species. It may be the young of *Conokephalina maia,* which occurs at the same locality but not in the same layer of rock.

A small cephalon about 2 mm. in length of about the same character as the one mentioned above, but differing from it in having a shorter frontal limb, occurs (C72) in the upper portion of the Ki-chóu limestone, 4 miles (6.4 km.) east of Fang-lan-chön, Shan-si, China. The locality of the cephalon first described is as follows:

Formation and Locality.—Middle Cambrian: (C70) Oolitic limestone about 30 feet (9 m.) above the base of the Ki-chóu limestone [Willis and Blackwelder, 1907, p. 144 (last list of fossils)], 4 miles (6.4 km.) south-southwest of Tung-yü, Shan-si, China.

Collected by Eliot Blackwelder.

Genus CREPICEPHALUS Owen.

Crepicephalus convexus Walcott.

Plate 13, Figures 16, 16*a–b*.

Crepicephalus convexus WALCOTT, 1911, Smithsonian Misc. Coll., vol. 57, No. 4, pp. 79–80, plate 14, figs. 11 and 11*a*. (Described and discussed as a new species essentially as below.)

The cranidium of this species differs from that of *C. damia* Walcott in its shorter frontal lobe, flatter frontal rim, and proportionately longer glabella. The

associated pygidium has a proportionately shorter axial lobe and its sides curve outward instead of inward.

Formation and Locality.—Middle Cambrian: (35r) Fu-chóu series, limestones near the base of the series just above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general section giving stratigraphic relations], collected in a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria, China.

Collected by J. P. Iddings and Li San.

Crepicephalus damia Walcott.

Plate 13, Figures 14, 14*a–b*.

Crepicephalus damia Walcott, 1905, Proc. U. S. Nat. Mus., vol. xxix, p. 92. (Described and discussed as a new species essentially as below.)

Cephalon semicircular in outline, with the postero-lateral angles terminating in round, somewhat incurved spines. Glabella moderately convex, with the sides narrowing slightly toward the front, which is broadly rounded; length a little greater than its width at the occipital furrow; marked by three pairs of furrows; the posterior pair extends obliquely inward and backward so as almost to separate a triangularly shaped lobe; second pair rather faint, extending directly inward a distance of about one-third the width of the glabella, and then curving slightly backward; anterior pair very faint; occipital furrow rather broad and strongly defined; occipital ring narrow at the ends, rounded, and rather strong in the central portions; dorsal furrow clearly defined on the sides, but obscure in front of the glabella.

Fixed cheeks about one-half the width of the glabella; posteriorly they slope downward into postero-lateral limbs that are about twice as long as the width of the fixed cheeks; toward the front the fixed cheeks slope abruptly downward and merge into the frontal limb; palpebral ridges low and broad, merging into the strong palpebral lobe; postero-lateral limbs grooved near the posterior margin by a strong furrow; frontal limb short, almost flat, and sloping abruptly from the front of the glabella down to the strong, nearly flat, frontal rim; the body of the associated free cheek is subquadrilateral in outline, marginal borders strong, clearly defined, and produced behind a strong, slightly curved, rounded spine.

Thorax unknown.

The associated pygidium is quadrilateral in outline, exclusive of the strong, slightly diverging postero-lateral spines, which are a little longer than the length of the pygidium; sides of the pygidium subparallel or slightly diverging toward the base of the spine; posterior margin nearly transverse; axial lobe prominent, convex, and reaching nearly to the posterior margin; the sides converge slightly toward the bluntly pointed posterior end; divided by three transverse furrows into three segments and a strong terminal portion, which is marked at the point where the axis slopes abruptly downward by a small node on each side; the pleural lobes are limited to a rather large anterior lobe, and an obscure secondary lobe, which appears to merge backward into the postero-lateral spine.

Surface apparently smooth under a strong lens; a few scattered punctæ occur on the glabella.

The largest cephalon has a length of 10 mm., with a width of 12 mm. at the palpebral lobes.

This species differs from *Crepicephalus iowensis* Owen [1852, p. 573], to which it appears to be most nearly related, by the form of the frontal limb and rim of the glabella and other details; the pygidium is not so broad, and it also differs in outline.

Formation and Locality.—Middle Cambrian: (C18) Dark gray oolitic limestone about 400 feet (120 m.) above the base of the Ch'ang-hia limestone [Blackwelder, 1907*a*, p. 33 (third list of fossils)], in cliffs 1 mile (1.6 km.) east of Ch'ang-hia, Shan-tung, China; also (C71), massive cliff-making limestone in the central portion of the Ki-chóu formation [Willis and Blackwelder, 1907, pp. 139 and 145 (second list of fossils)], 4 miles (6.4 km.) southwest of Tung-yü, Shan-si, China.

Collected by Bailey Willis and Eliot Blackwelder.

This species appears to be present in the two following localities, but the material is too poor to decide with certainty:

Middle Cambrian: (C21) Ocher-mottled phase of purple-gray limestone in the middle of the oolitic Ch'ang-hia formation [Blackwelder, 1907*a*, p. 33 (second list of fossils)], at Ch'ang-hia, and (C26) near the top of the black oolite group in the uppermost layers of the Ch'ang-hia limestone [idem (part of the last list of fossils)], 2 miles (3.2 km.) north-northeast of Ch'ang-hia, Shan-tung, China.

Collected by Eliot Blackwelder.

Crepicephalus magnus Walcott.

Plate 13, Figures 15, 15*a–b*.

Crepicephalus magnus Walcott, 1905, Proc. U. S. Nat. Mus., vol. xxix, p. 93. (Described as a new species essentially as below.)

The only portions of this species in the collection are a fragment of the posterior portion of the glabella and the outer portion of a large free cheek; the fragment shows that the glabella has a width at the base of 12 mm.; also, that there was a narrow, strong occipital groove and an occipital ring over 3 mm. in width.

The surface of the fragment of the glabella is marked by strong pustules, which give it a somewhat granulose appearance. The cast of the fragment of the interior of the free cheek indicates that it was pustulose and that the postero-lateral angle terminated in a long, curved spine.

The two fragments described are so distinctly marked by the coarse granulation, and the free cheek by its curved terminal spine, that there is little danger of confusing it with any other species.

Formation and Locality.—Middle Cambrian: (C48) Near the top of the cliffy oolitic limestone in the Ch'ang-hia limestone [Blackwelder, 1907*a*, p. 32 (part of last list of fossils)], at Ch'au-mi-tién, Shan-tung, China.

Collected by Eliot Blackwelder.

At a higher horizon in the Ch'ang-hia limestone a portion of a free cheek [fig. 15*a*] and a fragment of a glabella occur that may belong to this species.

Formation and Locality.—Middle Cambrian: (C25) Limestone about 50 feet (15 m.) below the Ku-shan shale in the uppermost beds of the Ch'ang-hia formation [Blackwelder, 1907*a*, p. 33 (part of the last list of fossils)], at Ch'ang-hia, Shan-tung, China.

Collected by Eliot Blackwelder.

Fragments of a strongly tuberculated free cheek occur in the Ch'ang-hia limestone at a horizon between (C48) and (C25) that appear to be similar to fragments of the free cheek from these horizons.

Formation and Locality.—Middle Cambrian: (C18) Dark gray oolitic limestone about 400 feet (120 m.) above the base of the Ch'ang-hia limestone [Blackwelder, 1907*a*, p. 33 (third list of fossils)], in cliffs 1 mile (1.6 km.) east of Ch'ang-hia, Shan-tung, China.

Collected by Eliot Blackwelder.

Genus LONCHOCEPHALUS Owen.

Lonchocephalus tellus (Walcott).

Plate 14, Figure 1.

Ptychoparia tellus WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 80. (Described as a new species essentially as below.)

All that is known of this species is the central part of the cephalon, exclusive of the free cheeks. The specimens occur on the surface of shaly limestone, and are probably somewhat compressed; their convexity is relatively slight. Glabella large, convex, and nearly as wide in front as at the base; three pairs of glabellar furrows are indicated on the somewhat eroded outer surface of two specimens; occipital furrow shallow, narrow, and rounded, but quite distinct; occipital ring narrow at the sides, increasing in width and inclining backward toward the middle, where it rises to the base of a strong spine, which is directed upward and backward; the spine is nearly straight, and about as long as the length of the head; dorsal furrow clearly defined on the sides and in front of the glabella.

Fixed cheeks slightly convex and less than half the width of the glabella; palpebral lobes rather large; palpebral ridges clearly defined and merging into the palpebral lobes; frontal limb short, slightly convex, and merging into the flattened frontal rim, the line of demarcation between the two being very slight; postero-lateral limbs small and short.

Surface unknown.

The largest cephalon in the collection has a length of 10 mm., with a width of 11 mm. at the outer edges of the palpebral lobes.

This species is most nearly related to *Lonchocephalus hamulus* Owen [1852, p. 576]. It differs in having wider fixed cheeks and in the proportion of length of the frontal limb and rim as compared with the glabella.

Formation and Locality.—Middle Cambrian: (C2) Lower shale member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 40 (part of the third list of fossils), and fig. 10 (bed 4 and 5), p. 38], 2 miles (3.2 km.) south of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Collected by Eliot Blackwelder.

Genus LIOSTRACINA Monke.

Liostracina MONKE, 1903, Jahrb. königl. preuss. Geol. Landesanstalt und Bergakademie, vol. XXIIII pt. 1, p. 114.

The generic name *Liostracina* simply precedes the name and description of the type species *L. krausei* Monke.

Liostracina krausei Monke.

Plate 11, Figure 8; Plate 14, Figures 2, 2*a*.

Liostracina krausei MONKE, 1903, Jahrb. königl. preuss. Geol. Landesanstalt und Bergakademie, vol. XXIII, pt. 1, p. 114, plate 3, figs. 10–17. (Species described and discussed.)

Ptychoparia ceus WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 76. (Described as a new species essentially as below.)

Cephalon, exclusive of free cheeks, transversely subrhomboidal in outline, broadly rounded in front, convex. Glabella conical, moderately convex, and marked by two pairs of short, shallow furrows that extend in but a short distance on the sides; occipital furrow rounded, very distinct, and continued outward on the postero-lateral limbs, where it is stronger and deeper; occipital ring narrow at the sides,

gradually increasing in width toward the center, where it is slightly convex, and marked at the center by a minute, sharp tubercle; dorsal furrow strong and rather deep about the glabella.

Fixed cheeks about the same width as the glabella, moderately convex; they slope gently from the dorsal furrow to the palpebral lobe, and backward to the furrow of the postero-lateral limb; in front they slope rather rapidly and merge into the frontal limb; palpebral lobes small and situated about their own length from the posterior margin of the cephalon; palpebral ridge very faint, scarcely perceptible except by turning the specimen in the light; frontal limb slightly convex, sloping gently downward, and divided midway by a longitudinal furrow that extends from the front of the glabella to the furrow within the frontal rim; each side of the longitudinal median furrow the frontal border extends outward and backward, merging into the fixed cheeks without any interruption in the convexity of the slope; frontal rim narrow, nearly flat, and separated from the frontal limb by a very shallow groove which is little more than a change in slope of the frontal limb to the nearly flat frontal rim; postero-lateral limbs very short.

Surface minutely granulose under a strong lens, with a few scattered, larger granules.

The largest cephalon of the species in the collection has a length of 4 mm., with a width at the palpebral lobes of nearly 5 mm.

This species is characterized by the longitudinal furrow in front of the glabella, which resembles the longitudinal furrow frequently seen in the frontal limb of the cephala of *Agnostus*.

Doctor Monke describes and illustrates a free cheek and two pygidia that he assigns to this species. He does not make comparisons with other genera, as he evidently planned to refer the genus again in a future contribution to the subject.

Formation and Locality.—Middle Cambrian: (C6) Thin, platy limestone in the upper shale member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 41 (second list of fossils), and fig. 10 (bed 12), p. 38], 2.5 miles (4 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Collected by Eliot Blackwelder.

Doctor Monke's specimens occur on slabs of limestone at Yen-tsy-yai, in Shan-tung.

Also from Middle Cambrian: (36f) Fu-chóu series, about 1,000 feet (305 m.) above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general stratigraphic relations], collected in a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria, China.

Collected by J. P. Iddings and Li San.

Genus PROAMPYX Frech.

Proampyx FRECH, 1902, Lethæa geognostica, pt. 1, Lethæa palæozoica, No. 2, p. 66. (Genus defined and discussed essentially as below.)

Dr. Fritz Frech proposed the genus *Proampyx* for *Anomocare acuminatum* Angelin [1854, edition of 1878, p. 26, plate 18, fig. 7] on account of the projection of the frontal border into a strong spine. He said [1902, p. 66]:

"The peculiar, very variously formed group of *Anomocare acuminatum* with pointed glabella, seems to be the forerunner of *Ampyx* and is called *Proampyx*. The difference from the typical *Anomocare* with rounded cephalic shield is striking. The separation of the genus *Proampyx* from the typical Conocephalidæ follows from the transitional forms *Arionellus sulcatus* [Angelin, pl. 18, fig. 6] and *A. difformis*

[Angelin, pl. 18, fig. 5]. The spine of *Ampyx acuminatus* is in well-preserved examples longer than in Angelin's illustration. The species reminds one most of *Ampyx nasutus* Dalman (*Orthoceras* limestone)."

Doctor Frech in his statement appears to have overlooked the fact that the spine of the genus *Ampyx* is a spinose extension of the front of the glabella, while the nasute projection of the frontal rim of *Anomocare acuminatum* is from an entirely different division of the cephalon of the trilobite and in no way can be correlated or compared with the glabella of *Ampyx*. On this account it is unfortunate that the name *Proampyx* was given.

A similar nasute projection of the frontal border occurs on the cephalon of the trilobite described as *Ptychoparia ? pernasutus* Walcott [1884, p. 49, plate 10, figs. 8, 8*b*]. The glabella of the latter species is quite unlike *Proampyx acuminatum*, being more like that of *Proampyx burea*. On this account it is doubtfully referred to *Proampyx*, until a further study can be made of all the forms in which the frontal border is extended into the nasute projection.

Proampyx burea (Walcott).

Plate 14, Figure 3.

Ptychoparia (*Proampyx*) *burea* WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 86. (Described as a new species.)

Cephalon, exclusive of the free cheeks, quadrilateral in outline, convex. Glabella convex, truncato-conical in outline, with the front broadly rounded; surface marked by two pairs of faintly indicated furrows; occipital furrow rounded, narrow, and distinct; occipital ring narrow at the sides, of medium width, and slightly convex toward the center; dorsal furrow of medium width, rather deep, and distinct.

Fixed cheeks convex, narrow, and about one-fourth the width of the glabella at the palpebral lobes; they slope gently back to the postero-lateral limbs, and abruptly downward in front of the narrow, rounded palpebral ridge to the frontal limb; postero-lateral limbs short, marked by a shallow furrow parallel to the margin; frontal limb short, and rising a short distance in front of the glabella into a nasute-like extension of the frontal rim, which rises up in front of the head; to the sides the frontal limb slopes abruptly downward and forward, forming a deep, wide groove with the frontal rim; frontal rim not separable from the frontal limb at the sides, but rising immediately in front of the glabella into a broad, nasute-like process, the height of which is unknown.

Surface unknown, except on the occipital ring, where it is marked by irregular, raised, inosculating lines that give it a granulose appearance.

The type and only specimen of the cephalon in the collection has a length of 10 mm., exclusive of the nasute-like projection on the frontal rim.

This species is clearly distinguished by the nasute-like projection on the frontal rim. It differs from *Proampyx acuminatum* [Angelin (1854), 1878, p. 26, plate 18, fig. 7] in a short frontal limb and the form of the nasute projection; also in the form of the glabella and other parts of the central portion of the cephalon.

Formation and Locality.—Upper Cambrian: (C61) A dense black limestone in the uppermost limestone member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 41 (third list of fossils), and fig. 10 (bed 13), p. 38], 3 miles (4.8 km.) southwest of Yen-chuang, Shan-tung, China.

Collected by Li San.

Genus PTEROCEPHALUS Roemer.

Pterocephalus asiaticus Walcott.

Plate 14, Figures 5, 5*a–b*.

Pterocephalus asiatica Walcott, 1905, Proc. U. S. Nat. Mus., vol. xxix, p. 67. (Described as a new species essentially as below.)

This species is represented by fragments of the anterior portion of the cephalon and of the pygidium. Glabella truncato-conical, moderately convex, narrowing gradually toward its rounded front; surface marked by three pairs of short furrows, the posterior of which separates rather small, oval lobes at the postero-lateral angles; occipital furrow narrow and slightly impressed; occipital ring of medium width and nearly flat; dorsal furrow narrow, but distinctly marked.

Fixed cheeks about two-thirds the width of the glabella opposite the palpebral lobes, slightly convex, and crossed by strong, low palpebral ridges; postero-lateral limbs unknown; frontal limb very broad and slightly concave; just in front of the glabella there is a faint depression formed by a slight change in the slope of the frontal limb that extends across a short distance in front of the palpebral lobe; frontal rim narrow, slightly rounded, and marked by irregular striæ parallel to the margin.

Surface of the glabella and fixed cheeks slightly roughened by what appear, under a strong lens, to be very fine granulations; the frontal limb is marked by irregular, raised lines that radiate from the front of the glabella and palpebral ridges outward toward the frontal margin; these raised lines are very irregular and more or less inosculating on and near the transverse depression of the frontal limb in front of the glabella and palpebral ridges.

On a cephalon 23 mm. in length the frontal limb has a length of 11.5 mm.; and the glabella and occipital ring, 11.5 mm., with a width at the palpebral lobes of 18 mm.

Fragments of the pygidium associated with the cephalon show that it had a slender, moderately convex axis, with more than eight rings, and that the pleural lobes were moderately convex, flattening out on a broad, planulate margin, the furrows on the axis extending out across the pleural lobes and nearly fading away on the broad margin; a faint trace of a very narrow, short pleural groove is shown on two of the pleural segments. Surface of the pygidium slightly roughened by what appears to be, under a strong lens, a very fine granulation.

Formation and Locality.—Middle Cambrian: (C12) Gray limestone near the top of the middle limestone member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 41 (part of the first list), and fig. 10 (bed 7), p. 38], 3.25 miles (5.2 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Collected by Eliot Blackwelder and Li San.

Pterocephalus busiris Walcott.

Plate 14, Figure 4.

Pterocephalus busiris Walcott, 1905, Proc. U. S. Nat. Mus., vol. xxix, p. 68. (Described as a new species essentially as below.)

This species is represented by two specimens of a pygidium that is quite distinct from the pygidium associated with *P. asiaticus*. The axis is elongate, slightly convex, and converging uniformly to about half its width at the posterior end; marked by eight or more narrow, distinct transverse furrows, that divide it into eight or more transverse rings and an elongate terminal portion. Pleural lobes slope gently from the dorsal furrow down toward the margin; they are marked by the continu-

ation of the distinct transverse furrows of the axis, that extend obliquely backward out to the margin, as far as can be determined; there is a slight indication of a pleural groove on the outer half of the pleural lobe. The pleural lobe is separated from the broad border by a slight elevation of the point of union of the border and pleural lobe, the slope of the two being approximately the same from the margin to the axis; a sharp ridge originates on the front side of each pleural segment a little distance out from the axis, and extends out across the border to the margin, leaving a concave space between the sharp ridges over the entire extent of the border; from the elongate terminal segment of the axis a narrow, double ridge continues backward to the border, which is here slightly incurved.

Surface finely granular under a strong lens.

This species differs from *P. asiaticus* [p. 146] in the form of the segments of the pleural lobes and margin.

Formation and Locality.—Upper Cambrian: (C61) a dense black limestone in the upper limestone member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 41 (third list of fossils), and fig. 10 (bed 13), p. 38], 3 miles (4.8 km.) southwest of Yen-chuang, Shan-tung, China.

Collected by Li San.

This species is also identified from Locality C54, Upper Cambrian, lower part of Ch'au-mi-tién limestone [Blackwelder, 1907*a*, p. 42 (part of last list of fossils)], near top of limestone knoll two-thirds of a mile (1.1 km.) west of Tsi-nan, Shan-tung, China.

Pterocephalus ? liches Walcott.

Plate 14, Figure 8.

Pterocephalus ? liches WALCOTT, 1911, Smithsonian Misc. Coll., vol. 57, No. 4, p. 80, plate 14, fig. 12. (Described and discussed as a new species essentially as below.)

This species is represented by four specimens of the pygidium. It is quite unlike the pygidium referred to *P. busiris* [plate 14, fig. 4], and with the discovery of entire specimens of the dorsal shield it may be found that the generic reference is incorrect.

The pygidia average 4 mm. in length and are finely preserved in the compact limestone matrix.

Formation and Locality.—Middle Cambrian: (35n) Fu-chóu series, limestones near the base of the series just above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general section giving stratigraphic relations], collected in a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria, China.

Collected by J. P. Iddings and Li San.

Genus SHANTUNGIA Walcott.

Shantungia WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 87. (Genus characterized.)
Not *Shantungia* LORENZ, 1906.

As there is but one species of this genus, the description of the species includes all that is known of the genus and species. The genus is characterized by the large palpebral lobes, nearly smooth, truncato-conical glabella, and the long, spinose extension of the front, which is unlike that of *Ampyx*, as the latter proceeds from the glabella, while the spine of *Shantungia* is from the frontal rim, in the same manner as that of *Proampyx acuminatum* Angelin [(1854) 1878, p. 26, plate 18, fig. 7], but it differs radically from the latter genus and species in the character of the glabella and palpebral lobes.

Genotype.—Shantungia spinifera Walcott.

Since the publication of this genus I received Dr. Monke's paper on Cambrian fossils in Shan-tung, in which he describes and illustrates, under the generic name *Teinistion* [1903, p. 117, plate 4, figs. 1–11], a trilobite that at first sight appears to be generically identical with *Shantungia*. The large palpebral lobes, narrow postero-lateral limbs, broad free cheeks, and conical glabella are much alike in both genera. The frontal limb of *Shantungia* with the nasute extension of the frontal border is, however, quite unlike the incurved, thin frontal margin of *Teinistion* [plate 9].

Shantungia spinifera Walcott.

Plate 11, Figures 9, 10; Plate 14, Figures 6, 6*a–e*.

Shantungia spinifera WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 87. (Described as a new species essentially as below.)

Cephalon, exclusive of free cheeks and frontal spine, subrhomboidal in outline, moderately convex. Glabella truncato-conical, slightly longer that its width at the base; at the postero-lateral angle of the glabella a small, low lobe extends out into and partly fills up the dorsal furrow; there is also a slight pit in the dorsal furrow, opposite a point where a second glabellar furrow usually occurs in similar glabellæ; occipital furrow narrow, distinctly defined at the sides but very shallow near the center; occipital ring slightly convex, strong, and of equal width from side to side; dorsal furrow deep at the sides and scarcely perceptible in front of the glabella.

Fixed cheeks about two-thirds as wide as the glabella; they rise abruptly from the deep dorsal furrow and then slope upward to the palpebral lobe; back of the palpebral lobe they drop somewhat abruptly to the postero-lateral limb, and in front to the furrow between the frontal limb and rim; palpebral ridge very slight, scarcely perceptible in most specimens; palpebral lobe large, rounded, and rising at the margins above the level of the fixed cheeks; rim of the broad, marginal border with an inward slope toward the fixed cheeks, but not very well-defined furrow such as usually occurs on the palpebral lobes; the length of the palpebral lobe is about one-half of the distance between the furrow in front of the frontal limb and the posterior margin of the cephalon; postero-lateral limb slender, and extending more than the width of the glabella outward from the dorsal furrow; frontal limb very short and scarcely separable from the downward slope of the front of the glabella; at the sides it merges into the fixed cheeks; it is separated from the frontal rim by a peculiar transverse furrow; the latter is formed of two slightly forward-arching, narrow furrows in front of the fixed cheeks, that merge into a very shallow furrow in front of the glabella; the central portion of the furrow arches slightly backward; the furrows are deepest opposite the antero-lateral angles of the glabella; frontal rim subtriangular in outline, nearly flat, and extending forward at the center to form the base of a long, slender, rounded spine.

Surface minutely punctate under a strong lens.

A cephalon 7 mm. in length, exclusive of the frontal spine, has a width of 9 mm. at the outer margin of the palpebral lobes; the glabella is 2.5 mm. at the base, and, with the occipital ring, is 5 mm. in length; the flat frontal rim and spine of a cephalon of about the same size have a length of about 8 mm., the spine, at the point where broken off, having a width of 1 mm.

I do not know of any other form closely related to this species. *Proampyx acuminatum* Angelin [(1854) 1878, p. 26, plate 18, fig. 7] has a similar nasute projection on the frontal rim, but it differs in the form of the glabella and palpebral lobes and other details of the cephalon. The same is true of the species described as *Ptychoparia ? pernasutus* Walcott [1884*a*, p. 49, plate 10, fig. 8].

Formation and Locality.—Middle Cambrian: (C6) thin, platy limestone in the upper shale member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 41

(second list of fossils), and fig. 10 (bed 12), p. 38], 2.5 miles (4 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Collected by Eliot Blackwelder.

Genus INOUYIA Walcott.

Inouyia WALCOTT, 1911, Smithsonian Misc. Coll., vol. 57, No. 4, pp. 80–81. (Described and discussed as a new genus essentially as below.)

The species referred to this genus are represented only by the cranidium. This in the genotype has a swollen, tumid frontal limb, small palpebral lobes, a convex and more or less subrectangular glabella, strong dorsal furrows about the glabella. and clearly marked glabellar furrows.

Surface apparently smooth, but with a strong lens it has a slightly roughened appearance caused by a shallow, irregular pitting.

Genotype.—Agraulos ? capax Walcott [1906, p. 580].

The swollen frontal limb, small palpebral lobes, and convex glabella at once suggest *Agraulos* [see plate 15] and in fact all of the species now referred to *Inouyia*, with the exception of *I. titiana* (Walcott) [plate 14, fig. 9], were at first referred to *Agraulos*. My reasons for separating them and creating the genus *Inouyia* are that the tumidity of the frontal limb is so pronounced as to become a marked feature and the glabella is more rectangular in the typical species. To these should be added the general effect of the cranidium [figs. 6, 6*a*], when compared directly with the cranidium of *Agraulos ceticephalus* (Barrande) [plate 15, figs. 1, 1*a*]. I think it quite probable that when entire specimens of the dorsal shield of the various species are available for comparison other differences will be found to exist between *Inouyia* and *Agraulos*.

In grouping the species under *Inouyia* some are found to be close to *Agraulos*, notably *I. abaris* (Walcott) [plate 14, fig. 16], *I. ? acalle* (Walcott) [plate 14, fig. 15], *I. ? regularis* (Walcott) [plate 14, fig. 18], and it is probable that with more complete specimens of the species they will be referred to a subgenus intermediate between *Inouyia* and *Agraulos*.

The wide fixed cheeks of *Inouyia capax* [figs. 11, 11*a*] are confined to this species, as all other species referred to *Inouyia* have relatively narrow fixed cheeks. The large eye of *I. ? inflata* (Walcott) and relatively narrow frontal limb serve to place it apart from the other species.

I am not at all satisfied with the arrangement of species under *Inouyia*, but in dealing with such fragmentary specimens much must be left to future discovery and closer work.

Attention is also called to *Ellipsocephalus hoffi* Barrande [1852, plate 10, figs. 26, 27], as in that species the frontal limb is convex and the glabella subrectangular.

The generic name is given in recognition of Dr. Kinos Ka Inouye, Director of the Imperial Geological Survey of Japan.

Inouyia abaris (Walcott).

Plate 14, Figure 16.

Agraulos abaris WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 42. (Described and discussed as a new species essentially as below.)

Glabella and fixed cheeks convex, subrhomboidal in outline, and strongly rounded in front. Glabella moderately convex; sides slightly converging; front broadly rounded; surface marked by three short and very slightly impressed furrows; occipital furrow shallow and arching slightly forward at the center; occipital ring narrow at the sides, gradually increasing in width to the broad base of a strong occipital spine.

Fixed cheeks slightly convex, about half the width of the glabella; between the glabella and palpebral lobes the cheeks are almost flat, posteriorly they slope rapidly downward to the short postero-lateral limbs, in front they also slope rapidly downward and merge into the frontal limb; palpebral lobes small; palpebral ridges narrow and faintly defined; frontal limb slightly prominent at the central portions, where it merges into the rounded frontal rim, the line of demarcation between the two being very slightly defined; at the sides the frontal rim narrows and is elevated about the lateral extension of the frontal limb; dorsal furrow very distinctly defined.

Surface apparently smooth under a strong lens, with the exception of very indistinct, irregular lines that radiate from the front of the glabella outward across the frontal limb.

The one specimen of the cephalon of this species in the collection has a length of 5 mm., exclusive of the occipital spine. The width at the palpebral lobes is 5 mm.

This species is clearly separated from other forms by its strongly defined glabella and prominent limb, which is formed by the union of the true limb and the frontal margin. It will probably be referred to some other genus when entire specimens of the dorsal shield are found.

Formation and Locality.—Middle Cambrian: (C9 and C7 just above C9, same section) Lower limestone member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 39 (the third and the last list of fossils), and fig. 8*a* (bed 33), p. 29], 3 miles (4.8 km.) and 2.2 miles (3.5 km.) southwest of Yen-chuang, Sin-t'ai district, Shantung, China.

Collected by Eliot Blackwelder.

Inouyia ? acalle (Walcott).

Plate 14, Figure 15.

Agraulos acalle WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 43. (Species described as below.)

Central portions of the cephalon, exclusive of free cheeks, moderately convex. Glabella truncato-conical, convex, short, scarcely more than one-half the length of the cephalon, and without traces of furrows; occipital furrow not much more than a depressed line; occipital ring broad, almost subtriangular in outline, and rising at the center to a small node.

Fixed cheeks about as wide as the glabella, strongly convex, and merging into a frontal limb of about equal width and convexity; palpebral lobe minute, situated opposite the central portions of the glabella; postero-lateral limbs short, and marked by a narrow furrow parallel to the margin.

Surface smooth under a strong lens.

The cephala vary in length from 3 to 4 mm. A specimen 3 mm. in length has a width of 2.5 mm. at the palpebral lobes.

Formation and Locality.—Middle Cambrian: (C12) Gray limestone near the top of the middle limestone member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 41 (part of the first list), and fig. 10 (bed 7), p. 38], 3.25 miles (5.2 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Collected by Eliot Blackwelder and Li San.

Inouyia ? armata (Walcott).

Plate 14, Figures 17, 17*a*.

Agraulos armatus WALCOTT, 1906, Proc. U. S. Nat. Mus., p. 576. (Species described as below.)

This species is represented by a finely preserved specimen of the central portions of the cephalon, exclusive of the free cheeks. The glabella is strongly convex, with the sides slightly converging toward the rounded front; it is marked by three pairs

of short, obscure glabellar furrows close to the dorsal furrow; the occipital furrow is indicated by a short, scarcely discernible depression toward the side of the union of the glabella and occipital ring; occipital ring a little narrower than the glabella and extended backward into an extraordinarily strong spine, which is nearly as broad as the glabella, to a point corresponding in length with the glabella; the posterior termination of the spine is not preserved; on the side view the surface of the glabella extends backward continuously with that of the occipital ring and spine, on the same plane; the strong backward extension of the glabella recalls some of the large occipital spines in some species of *Microdiscus*; dorsal furrow deep, and strongly developed on the sides and in front of the glabella.

Fixed cheeks about as wide as the glabella, strongly convex, and merging into a convex frontal limb that is wider and more convex than the fixed cheeks; palpebral lobes small; a narrow, clearly defined palpebral ridge extends obliquely backward across the fixed cheek from the antero-lateral angle of the glabella.

Surface minutely granular under a very strong lens. The type specimen has a length of 5 mm., exclusive of the combined occipital ring and spine.

This species is most nearly related to *I. melie* [p. 153] and *I. ? acalle* [p. 150]. It differs from them in the form of the convex fixed cheeks and frontal limb, the presence of palpebral ridges, the extraordinarily strong occipital spine, and in having a proportionately shorter glabella.

Formation and Locality.—Middle Cambrian: (C75) Limestone near the base of the Ki-chóu formation [Willis and Blackwelder, 1907, p. 143], 4.5 miles (7.2 km.) south of Wu-t'ai-hién, Shan-si, China.

Collected by Eliot Blackwelder.

Inouyia capax (Walcott).

Plate 14, Figures 11, 11*a*.

Agraulos (?) capax Walcott, 1906, Proc. U. S. Nat. Mus., vol. xxx, p. 580. (Species described and discussed essentially as below.)

As indicated by the central portions of the cephalon exclusive of the free cheeks, the cephalon of this species is semicircular in outline, and moderately convex. The glabella narrows slightly from the base to its rounded front, which springs from the point where the palpebral ridges pass into the dorsal furrow; the surface of the glabella is marked by three pairs of short, slightly impressed glabellar furrows that divide the glabella into a posterior subtriangular lobe, two narrow lobes, and a larger front terminal lobe; occipital furrow rounded, not very deep, and slightly wider at the sides than in the center; occipital ring narrow at the sides, widening toward the center, where there is a low, small node near the posterior margin; dorsal furrow narrow, deep in front, and shallow at the sides of the glabella.

Fixed cheeks broad, rising gently from the dorsal furrow to the palpebral lobes; they slope gradually to the posterior furrow, and, in front of the palpebral ridges, rather rapidly to the broad furrow defining the frontal limb; palpebral lobe small, narrow, and passing in front into a narrow palpebral ridge, which crosses the fixed cheek to the antero-lateral angle of the glabella; frontal limb separated from the glabella by a narrow, deep furrow, which widens out on each side; the limb is strongly convex immediately in front of the glabella, where it rises on some examples into a transverse boss; in other specimens it is not much higher than the general elevation of the glabella.

Surface marked by shallow, irregular, minute pits when examined with a strong lens. The cephalon of the largest specimen in the collection has a length of 7 mm., with a width of 12 mm. at the palpebral lobes.

This species, at first sight, might be taken for a broad form of *Inouyia melie* [p. 153], but on closer examination it is seen that the glabella is nearly rectangular instead of truncato-conical, the fixed cheeks are more than twice the width, and glabella narrower, in specimens of the same size. The palpebral ridges of *Inouyia capax* are also unlike those of *I. melie*.

Formation and Locality.—Middle Cambrian: (C70) Oolitic limestone about 30 feet (9 m.) above the base of the Ki-chóu limestone [Willis and Blackwelder, 1907, p. 144 (last list of fossils)], 4 miles (6.4 km.) south-southwest of Tung-yü, Shan-si, China.

Collected by Eliot Blackwelder.

Inouyia divi (Walcott).

Plate 14, Figures 13, 13*a*, 14 (?).

Agraulos divi WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 45. (Species described as below.)

This species is represented by portions of the central parts of the cephalon. The glabella is convex truncato-conical in outline, the width of the base and the length being the same; three pairs of glabellar furrows are very slightly indicated; occipital furrow shallow and broad; occipital ring narrow at the sides, gradually widening toward the center, very slightly convex, and without an occipital spine.

Fixed cheeks about as wide as the front of the glabella and nearly flat opposite the palpebral lobes; posteriorly they slope slightly into a strong groove parallel to the posterior margin, and in front the slope is slight down to a broad, slightly indicated transverse furrow; palpebral lobes unknown; only a trace of the palpebral ridge is shown; frontal limb convex, broad, and extending to the frontal margin without any trace of a line of demarcation between it and the frontal rim; a broad, shallow transverse furrow extends in front of the glabella and outward across the cheeks below and in front of the palpebral ridges; dorsal furrow broad and shallow.

Surface finely papillose under a strong lens.

The largest cephalon of the collection has a length of 9 mm.

This species is characterized by its short glabella, broad dorsal furrow, transverse furrow in front of the glabella, and strong frontal limb.

Formation and Locality.—Middle Cambrian: (C24) Near top of black oolite group in the uppermost layers of the Ch'ang-hia formation [Blackwelder, 1907*a*, p. 33 (part of last list of fossils)], 2 miles (3.2 km.) east of Ch'ang-hia, Shan-tung; also (C1), lower shale member of the Kiu-lung group [idem, pp. 37 and 40 (part of the third list of fossils), and fig. 10 (bed 4), p. 38], 2 miles (3.2 km.) south of Yen-chuang, and (C5) lower limestone member of the Kiu-lung group [idem, pp. 37 and 39 (first list of fossils), and fig. 8*a* (bed 30), p. 29], 3.2 miles (5.1 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Collected by Eliot Blackwelder.

Inouyia ? inflata (Walcott).

Plate 14, Figure 10.

Ptychoparia inflata WALCOTT, 1906, Proc. U. S. Nat. Mus., vol. XXX, p. 587. (Species described and discussed essentially as below.)

This species is represented by two specimens of the central portions of the cephalon, exclusive of the free cheeks. The parts preserved indicate that the cephalon was rather strongly convex, and semicircular in outline. Glabella moderately convex, with the length and width at the base equal; the sides converge slightly toward the rather broadly rounded antero-lateral angles; front nearly transverse; surface marked by a clearly defined posterior pair of furrows, which extend obliquely inward and backward, separating a subtriangular postero-lateral

lobe; a second pair of short, lightly defined furrows occurs about one-third the distance between the posterior furrows and the front of the glabella; occipital furrow rather broad and shallow toward the center, narrower and deeper at the sides; occipital ring narrow at the sides, increasing in width toward the center, where it is rather broad and slightly convex; dorsal furrow clearly defined at the sides and front of the glabella.

Fixed cheeks about one-third the width of the glabella, convex, rising from the dorsal furrow and curving over to the facial sutures and the furrows separating them from the palpebral lobes; palpebral lobes narrow, slightly elevated, and about one-third the length of the cephalon; palpebral ridges indicated more by the depressions in front of them than by their elevation above the general surface of the fixed cheeks; postero-lateral limb short, and marked by a broad, shallow furrow within the strong, rounded posterior rim; frontal limb convex, inflated at the center so as to form an elongate swelling somewhat similar to that of *Inouyia melie* the line of demarcation between the fixed cheeks and the frontal limb is rather indefinite, the fixed cheeks merging into the downward sloping surface of the frontal limb; there is no line of demarcation to indicate a distinct frontal rim.

Surface smooth to the unaided eye, and under a strong lens slightly roughened with what appear to be irregular, inosculating, very slightly elevated lines, and a few low, scattered tubercles. The type and largest specimen of the cephalon has a length of 9 mm.

This species at first suggests *Inouyia melie* owing to the swelling on the frontal limb; the glabella, however, is much broader in proportion to its length, and its furrows are those of *Ptychoparia* rather than *Agraulos*.

Formation and Locality.—Middle Cambrian: (C69) Limestone in shales about 65 feet (19.5 m.) above the base of the Ki-chóu limestone [Willis and Blackwelder, 1907, p. 145 (first list of fossils)], 4 miles (6.4 km.) east of Fang-lan-chön, Shan-si, China.

Collected by Eliot Blackwelder.

Inouyia melie (Walcott).

Plate 14, Figures 12, 12*a*.

Agraulos (?) melie Walcott, 1906, Proc. U. S. Nat. Mus., vol. xxx, p. 581. (Species described essentially as below.)

Central portions of cephalon, exclusive of the free cheeks, convex. Glabella truncato-conical, convex, about one-half the length of the cephalon, and marked by three pairs of short, faintly impressed glabellar furrows, and a narrow, median, longitudinal ridge; occipital furrow transverse, rounded, shallow, and fading out toward the center of the glabella; occipital segment narrow at the sides, widening rapidly to the central portion, which is as high as the glabella at the back, and sloping toward the occipital furrow at the base of the glabella; a minute node occurs at the center of the segment; dorsal furrow shallow, but strongly outlined.

Fixed cheeks narrow, elevated at the palpebral lobes, and sloping toward the glabella; a narrow ridge extends from the anterior outer edge of the furrow on the inner side of the palpebral lobe to the furrow in front of the antero-lateral angle of the glabella, which corresponds to the palpebral ridge; palpebral lobe long, narrow, and separated from the fixed cheek by a narrow furrow; frontal limb convex, rising to a prominent boss or swelling in front of the glabella, from which it is separated by a strong furrow; at the sides the frontal limb is narrow and merged into the narrow, fixed cheeks; postero-lateral limbs short, narrow, and separated from the fixed cheeks by a narrow, shallow furrow.

Surface finely punctuate under a strong lens. The largest cephalon in the collection has a length of 6 mm.

This species is characterized by the tumid frontal limb and the ridge within the palpebral lobe on the fixed cheek.

Formation and Locality.—Middle Cambrian: (C70) Oolitic limestone about 30 feet (9 m.) above the base of the Ki-chóu limestone [Willis and Blackwelder, 1907, p. 144 (last list of fossils)], 4 miles (6.4 km.) south-southwest of Tung-yü, Shan-si, and (C75) limestone near the base of the Ki-chóu formation [idem, p. 143], 4.5 miles (7.2 km.) south of Wu-t'ai-hién, Shan-si, China.

Collected by Eliot Blackwelder.

Inouyia ? regularis (Walcott).

Plate 14, Figure 18.

Agraulos regularis WALCOTT, 1906, Proc. U. S. Nat. Mus., vol. XXX, p. 578. (Species described essentially as below.)

This species is represented by a few specimens of the central portions of the cephalon, exclusive of the free cheeks. These indicate that the cephalon was rather strongly convex, and semicircular in outline. Glabella convex, truncato-conical, rounded in front, and with traces of two pairs of short glabellar furrows that divide it into three subequal portions; occipital furrow narrow but clearly defined; occipital ring narrow at the sides, increasing slightly in width toward the center, where it rises to form the base of a small node; dorsal furrow deep and rather broad.

Fixed cheeks convex, rising abruptly from the dorsal furrow, the posterior furrow of the cephalon, and the anterior margin; in front they merge into the rounded, convex frontal limb with a trace of an intervening furrow and narrow palpebral ridge; palpebral lobes small and situated opposite the central portion of the glabella.

Surface, under a strong lens, shows traces of being very finely punctate. The average length of three specimens of the cephalon is 2 mm.

The cephalon representing this species has the rounded, full fixed cheeks and frontal limb of *Inouyia ? acalle* [p. 150], but it differs in having a proportionately shorter and broader glabella, and in being broader between the facial sutures.

Formation and Locality.—Middle Cambrian: (C73) Conglomeritic limestones near the top of the Ki-chóu limestone [Willis and Blackwelder, 1907, p. 145 (fourth list of fossils)], 4 miles (6.4 km.) east of Fang-lan-chön, Shan-si, China.

Collected by Eliot Blackwelder.

Inouyia thisbe Walcott.

Plate 14, Figure 21.

Inouyia ? thisbe WALCOTT, 1911, Smithsonian Misc. Coll., vol. 57, No. 4, p. 81, plate 14, fig. 14. (Described and discussed as a new species essentially as below.)

This species is represented by two broken specimens of the cranidium. These show that the glabella is much like that of *Inouyia titiana* (Walcott) [plate 14, fig. 9]; also the fixed cheeks and palpebral lobes. It differs in the transverse swelling of the frontal limb. In *I. thisbe* the frontal limb rises with a slight slope in front of the glabella, and curves gently downward to the margin without a trace of a frontal border as in *Inouyia inflata* (Walcott) [plate 14, fig. 10]. In *I. titiana* the frontal limb is abruptly convex and there is an almost flattened border.

The surface of *I. thisbe* is distinctly punctate and in this respect resembles *Agraulos dryas* [plate 14, fig. 20].

The type specimen of the cranidium has a length of 5.5 mm.

Formation and Locality.—Middle Cambrian: (C28) Thin-bedded oolitic limestone at the base of the Ch'ang-hia limestone [Blackwelder, 1907*a*, p. 32 (first list of fossils), and fig. 6 (bed 20), p. 25], just above the shales in the face of the cliff 1 mile (1.6 km.) east-southeast of Ch'ang-hia, Shan-tung, China.

Collected by Eliot Blackwelder.

Inouyia titiana (Walcott).

Plate 14, Figure 9.

Ptychoparia titiana WALCOTT, 1905, Proc. U.S. Nat. Mus., vol. XXIX, p. 81. (Species described essentially as below.)

Cephalon quadrilateral in outline, exclusive of the free cheeks, moderately convex. Glabella gently convex; broadest at the base, narrowing midway, and with the sides nearly parallel from the center to the broadly rounded front; glabellar furrows shallow; there are three on each side that penetrate to the central third of the glabella and divide it into two small central lobes, a short terminal lobe, and a posterior lobe that is broad at the sides and narrow toward the central third; occipital furrow narrow; occipital ring rounded at the sides and gradually thickening toward the center to form the base of a rather strong spine of unknown length; dorsal furrow shallow, but clearly defined.

Fixed cheeks of medium width, about two-thirds the width of the glabella; palpebral lobes central and about one-third the length from the posterior to the frontal margins of the cephalon; palpebral ridge narrow, clearly defined; it starts near the front line of the glabella and extends obliquely backward and merges into the rim of the palpebral lobe; postero-lateral limbs short and marked by a broad, shallow furrow; frontal limb convex, prominent, about as long as the fixed cheeks at the eye-lobes; at the front it slopes into the rounded groove back of the narrow, slightly flattened frontal rim.

Surface slightly roughened over the central portions; on the frontal limb a network of fine, irregular, raised lines extends from the dorsal furrow and palpebral ridges to the furrow inside the frontal rim.

This species is associated with *Anomocarella thraso* [p. 208]. Its strong frontal limb and occipital spine distinguish it from other species.

Formation and Locality.—Middle Cambrian: (C7) Lower limestone member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 39 (last list of fossils), and fig. 8*a* (bed 33), p. 29], 2.2 miles (3.5 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung, and (C28) thin-bedded oolitic limestone at the base of the Ch'ang-hia limestone [idem, p. 32 (first list of fossils), and fig. 6 (bed 20), p. 25], just above the shales in the face of the cliff 1 mile (1.6 km.) east-southeast of Ch'ang-hia, Shan-tung, China.

Collected by Eliot Blackwelder.

Genus AGRAULOS Corda.

Agraulos CORDA, 1847, Prodrom einer Monographie der böhmischen Trilobiten, p. 26.

In order that direct comparison may be made with illustrations of the type species, one of the figures given by M. Joachim Barrande is reproduced [plate 15, fig. 1*a*] and a photograph of two specimens [plate 15, fig. 1] from the typical locality in Bohemia. As we have only the cranidium of the various species from China referred to *Agraulos*, the generic identification is made subject to revision on the discovery of entire specimens. There will also be differences of opinion as to the species included tentatively under the genus, as there is considerable variation among the cranidia of *A. nitida* [plate 15, fig. 2], *A. obscura* [plate 15, fig. 4], *A. uta* [plate 15, fig. 7], and *A. vicina* [plate 15, fig. 8].

Agraulos abrota Walcott.

Plate 15, Figure 3.

Agraulos abrota WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 43. (Characterized as a new species as below.)

This species is represented by several small cephala, exclusive of the fixed cheeks. It is closely related to *Agraulos dryas* [p. 157] but differs from it in its greater width, stronger convexity of the glabella, and greater downward slope of the frontal margin. The surface is also more minutely punctate than that of *Agraulos dryas*. The largest specimen is a little less than 3 mm. in length.

Formation and Locality.—Middle Cambrian: (C23) Upper part of thin-bedded gray oolitic limestone at the base of the Ch'ang-hia formation [Blackwelder, 1907*a*, p. 32 (second list of fossils), and fig. 6 (bed 20), p. 25], 50 feet (15 m.) below the base of the cliffs 1 mile (1.6 km.) east-southeast of Ch'ang-hia, Shan-tung, China.

Collected by Eliot Blackwelder.

Agraulos dirce Walcott.

Plate 15, Figure 5.

Agraulos dirce WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 44. (Described and discussed as a new species essentially as below.)

This species is represented by the central portions of the cephalon, exclusive of the fixed cheeks. The surface is depressed, convex, with the glabella rising but little above the general surface at the front, and but moderately convex at the base. Glabella truncato-conical, indistinctly defined from the frontal rim and at its base from the occipital ring; without traces of furrows; occipital furrow indicated only by the very slight convexity of the occipital ring.

Fixed cheeks about three-fourths of the width of the glabella; posteriorly they merge into the short postero-lateral limbs and toward the front into the broad, gently convex frontal limb, which continues uninterruptedly to the anterior margin of the cephalon; palpebral lobes small; palpebral ridges indicated by a dropping down of the fixed cheek at the place where the ridges usually occur.

This species recalls the general form of *Agraulos strenuus* Billings [1872*b*, p. 473, fig. 10]. It differs in being less convex, in its broader fixed cheek, and short occipital ring. It also differs in its wider fixed cheeks from *A. dolon*, which occurs at about the same geologic horizon.

The largest cephalon in the collection has a length of 11 mm., and the same width at the palpebral lobes.

Formation and Locality.—Middle Cambrian: (C52) in the lower part of the lower limestone member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 39 (second list of fossils), and fig. 7 (bed 22), p. 27], near base of cliffs in mountain 1,000 feet (305 m.) high, 3 miles (4.8 km.) north-northeast of Sin-t'ai-hién, Shan-tung, China.

Collected by Eliot Blackwelder.

Agraulos dolon Walcott.

Plate 15, Figure 6.

Agraulos dolon WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 45. (Described and discussed as a new species essentially as below.)

This species is represented by the central portions of the cephalon, exclusive of the free cheeks. The glabella and fixed cheeks are convex, somewhat rhomboidal in outline; glabella convex, narrowing slightly toward the broadly rounded frontal margin; posteriorly it is separated from the occipital ring by a very faint, narrow

furrow; there are no traces of glabellar furrows; occipital ring strong, and merged into the broad, subtriangular base of a strong, short spine; dorsal furrow shallow but sufficiently strong to mark the line of demarcation between the glabella, fixed cheeks, and frontal limb.

Fixed cheeks a little more than half the width of the glabella, rising rapidly from the facial suture and merging into the frontal limb anteriorly and into the short postero-lateral limbs at the back; palpebral lobes small and narrow; palpebral ridges broad but faintly defined; they extend from the antero-lateral angle of the glabella outward and slightly backward to where they unite with the palpebral lobe; frontal limb slightly convex from the front of the glabella to the broadly rounded front margin.

Surface apparently smooth.

The largest specimen in the collection has a length of 9 mm., exclusive of the occipital spine.

This species strongly suggests *Agraulos strenuus* Billings [1872*b*, p. 473, fig. 10] from the *Paradoxides* zone of Newfoundland; it differs in the form of the frontal limb and border. In *A. dolon* the frontal limb arches gently downward and forward to the margin, while in *A. strenuus* it is nearly flat and slightly convex between the glabella and the margin. The glabella of the latter is also proportionately longer.

It differs from *Agraulos dirce* [p.156] in its greater convexity, more clearly defined glabella, and strong occipital spine.

Formation and Locality.—Middle Cambrian: (C7) Lower limestone member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 39 (last list of fossils), and fig. 8*a* (bed 33), p. 29], 2.2 miles (3.5 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Collected by Eliot Blackwelder.

Agraulos dryas Walcott.

Plate 14, Figure 20.

Agraulos dryas Walcott, 1905, Proc. U. S. Nat. Mus., vol. xxix, p. 36. (Described as a new species essentially as below.)

Glabella and fixed cheeks convex; rhomboidal in outline. Glabella convex, short, narrowing slightly toward the rounded front, without traces of furrows; occipital furrow broad, very faintly defined; occipital ring very narrow at the sides, broadening out rapidly to a blunt point so as to be almost triangular.

Fixed cheeks about two-thirds the width of the glabella, and sloping slightly downward to the small palpebral lobes, which are situated about midway between the posterior and the front margin of the cephalon; back of the palpebral lobes the fixed cheeks slope rapidly to broad, short, postero-lateral limbs; palpebral lobes short, form unknown; palpebral ridges not distinguished on the downward slope of the fixed cheeks toward the frontal limb; frontal limb and frontal rim nearly as long as the glabella; very slightly convex and separated from each other by a shallow, slightly defined depression; dorsal furrow shallow but clearly defined.

Entire surface marked by numerous rather strong punctæ; also very fine, almost microscopic, irregular, elevated, more or less concentric striæ on the glabella.

Length of cephalon, 3.5 mm.

This species is represented by one specimen. It is strongly characterized by its punctate surface and general form.

Formation and Locality.—Middle Cambrian: (C29) Near the top of the cliffy limestone in the Ch'ang-hia limestone [Blackwelder, 1907*a*, p. 32 (part of last list of fossils)], 1 mile (1.6 km.) west of Ch'ang-hia, Shan-tung, China.

Collected by Eliot Blackwelder.

Agraulos nitida Walcott.

Plate 15, Figures 2, 2*a*–*b*.

Agraulos nitida WALCOTT, 1906, Proc. U. S. Nat. Mus., vol. xxx, p. 576. (Described as a new species essentially as below.)

This species is represented by the central portions of the cephalon, exclusive of the free cheeks; the front within the facial sutures is strongly rounded, indicating a semicircular outline for the cephalon, which was moderately convex. Glabella truncato-conical, moderately convex, and not very clearly defined from the fixed cheeks and frontal limb; there are no traces of glabellar furrows; occipital furrow represented by a slight depression at the base of the glabella; occipital ring very narrow at the sides, thickening rapidly toward the center so as to give it a subtriangular outline, the apex of which terminates in a small spine of unknown length; dorsal furrow indicated by the difference in slope of the glabella and fixed cheeks and frontal limb.

Fixed cheeks less than one-half the width of the glabella, nearly flat opposite the palpebral lobes, and sloping gently downward to the posterior furrow, and to the front to merge into the frontal limb, which is slightly convex; palpebral lobes about one-fourth the length of the cephalon.

Surface slightly roughened by what appears to be a minutely granulated surface as shown by a strong lens.

The largest cephalon in the collection has a length of 5 mm.

This species is most nearly related to *Agraulos dolon* [p. 156]. The cephalon of the latter differs in being longer in proportion to the width, and in having broader fixed cheeks.

Formation and Locality.—Middle Cambrian: (C75) Limestone near the base of the Ki-chóu formation [Willis and Blackwelder, 1907, p. 143], 4.5 miles (7.2 km.) south of Wu-t'ai-hién, Shan-si, China.

Collected by Eliot Blackwelder.

Agraulos obscura Walcott.

Plate 15, Figure 4.

Agraulos obscura WALCOTT, 1906, Proc. U. S. Nat. Mus., vol. xxx, p. 577. (Described as a new species.)

This species is represented by the central portions of the cephalon, exclusive of the free cheeks. The glabella and fixed cheeks moderately convex; glabella truncato-conical, with the front margin gently curved and antero-lateral angles slightly rounded; the postero-lateral angles are more broadly rounded and pass into the line of the posterior margin of the occipital ring without interruption by the occipital furrow; surface of glabella smooth, with the exception of some very slight indications of a posterior pair of furrows; occipital furrow shallow, and fading out before reaching the dorsal furrow; occipital ring narrow at the ends, broadening and rising toward the center to form the base of what may be a short spine, or a slight upward projection of the central portion of the posterior margin of the ring; dorsal furrow of medium width and well defined at the sides and front of the glabella.

Fixed cheeks narrow, convex, rising into narrow ridges that anteriorly form a node or swelling where they merge into the frontal limb; posteriorly they slope down to merge with the postero-lateral limb; palpebral lobes small, somewhat elevated, and separated from the fixed cheeks by a shallow furrow; there does not appear to be any palpebral ridge; postero-lateral limb about as long as the width of the glabella in front; it is marked by a shallow furrow within the slightly rounded

posterior margin; frontal limb and rim in front of the glabella moderately convex; on each side a broad, shallow furrow indicates that the dividing line between the frontal limb and rim was about half way between the front of the glabella and the frontal margin of the cephalon.

Surface apparently smooth. The type specimen of the cephalon is 7.5 mm. in length.

This species indicates a type somewhat similar to *Inouyia melie* [p. 153]. It differs from the latter in not having a swollen frontal limb, in the absence of palpebral ridges, and in having a smaller, flat occipital ring. From *Inouyia divi* [p. 152] it differs in the presence of the side furrows delimiting the frontal limb and rim, narrower and more convex fixed cheeks, and less strongly marked occipital ring.

Formation and Locality.—Middle Cambrian: (C69) Limestone in shales about 65 feet (19.5 m.) above the base of the Ki-chóu limestone [Willis and Blackwelder, 1907, p. 145 (first list of fossils)], 4 miles (6.4 km.) east of Fang-lan-chön, Shan-si, China.

Collected by Eliot Blackwelder.

Agraulos sorge Walcott.

Plate 15, Figure 9.

Agraulos sorge WALCOTT, 1911, Smithsonian Misc. Coll., vol. 57, No. 4, p. 82, plate 15, fig. 1. (Described and discussed as a new species essentially as below.)

This species is represented by a single specimen of the central portions of the cephalon. Among the Chinese species referred to *Agraulos* it may be compared with *A. dryas* Walcott [plate 14, fig. 20], from which it is readily distinguished by its broader, less convex glabella and its almost smooth, instead of strongly punctate, surface.

Agraulos sorge appears to have had a strong occipital spine that projected upward and backward from the occipital ring; only the base of the spine is preserved.

Surface slightly roughened by a minute, irregular, shallow pitting.

Formation and Locality.—Middle Cambrian: (35n) Fu-chóu series, limestones near the base of the series just above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general section giving stratigraphic relations], collected in a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria, China.

Collected by Eliot Blackwelder.

Agraulos uta Walcott.

Plate 15, Figure 7.

Agraulos uta WALCOTT, 1906, Proc. U. S. Nat. Mus., vol. xxx, p. 579. (Discussed as a new species as below.)

This species is based upon a single cephalon, preserving the glabella and fixed cheeks, and frontal rim. It resembles *Inouyia capax* [p. 151], but differs in having a narrower fixed cheek, less convex and swollen limb, and flatter frontal rim. The glabella is without traces of furrows, and the occipital ring is separated from it by a very shallow, scarcely noticeable, transverse furrow; the frontal limb is rather broad and slightly swollen in front of the glabella; the general plane of the frontal limb and fixed cheeks is the same from a line drawn through the posterior end of the palpebral lobes.

Surface slightly roughened by a fine network of narrow, slightly elevated, inosculating lines. The type specimen has a length of 5.5 mm.

Formation and Locality.—Middle Cambrian: (C 75) Limestone near the base of the Ki-chóu formation [Willis and Blackwelder, 1907, p. 143], 4.5 miles (7.2 km.) south of Wu-t'ai-hién, Shan-si, China.

Collected by Eliot Blackwelder.

Agraulos vicina Walcott.

Plate 15, Figure 8.

Agraulos vicina WALCOTT, 1906, Proc. U. S. Nat. Mus., vol. xxx, p. 579. (Described as a new species.)

This species is represented by three specimens of the moderately convex central portions of the cephalon, exclusive of the free cheeks. Glabella conical, convex, and without traces of glabellar furrows; occipital furrow transverse and clearly defined; occipital ring rather strong, transverse, and slightly convex; dorsal furrow rounded, of medium width, and clearly defined at the sides and front of the glabella.

Fixed cheeks about as wide as the glabella, moderately convex, and sloping forward and slightly downward into the frontal limb; palpebral lobes small, situated opposite the central portion of the glabella; palpebral ridges narrow, slightly elevated, and extending from the anterior end of the palpebral lobe to a point corresponding to the antero-lateral angle of the glabella; postero-lateral limb short, and marked by a shallow furrow within its posterior margin; frontal limb short, convex in front of the glabella, arching slightly backward on each side to merge into the fixed cheeks; frontal rim broad, slightly convex, and separated by a shallow, slightly defined furrow at the angle formed by the union of the sloping frontal limb with the nearly flat frontal rim.

Surface roughened as seen by a high magnifying power. The largest specimen in the collection has a length of 3 mm.

This species is characterized by its narrow, conical glabella, convex frontal limb that merges into the convexity of the fixed cheeks, and the presence of a distinct frontal rim. In the latter respect it approaches *Inouyia capax* [p. 151] and *Agraulos uta* [p. 159]. It differs widely from *I. capax* and less so from *A. uta* in its narrow, conical glabella and the form of its frontal limb.

Formation and Locality.—Middle Cambrian: (C 70) Oolitic limestone about 30 feet (9 m.) above the base of the Ki-chóu limestone [Willis and Blackwelder, 1907, p. 144 (last list of fossils)], 4 miles (6.4 km.) south-southwest of Tung-yü, Shan-si, China.

Collected by Eliot Blackwelder.

Genus PAGODIA Walcott.

Pagodia WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. xxix, p. 63. (Genus described.)

This genus is proposed to include a few species from the Upper Cambrian zone which do not appear to be closely related to any described genus. Only the central portions of the cephalon are available for description.

Glabella oblong, with obscure traces of furrows at the sides. Eyes small, central, and without trace of palpebral ridge. Facial sutures cut the frontal margin opposite the eye-lobe and the posterior margin within the postero-lateral angles.

Thorax unknown.

An associated pygidium has a conical, segmented axis, narrow pleural lobes, and smooth, undefined margin.

Genotype.—*Pagodia lotos* Walcott.

The four species of this genus all have a similar type of surface, consisting of shallow punctæ of moderate size, with very fine punctæ, visible only under a strong

lens, between the larger punctæ. The species now referred to the genus are *Pagodia bia* Walcott, *P. dolon* Walcott, *P. lotos* Walcott, and *P. macedo* Walcott. I was at first inclined to refer these forms to *Dolichometopus*, but they differ from the type of the latter, *Dolichometopus svecicus* Angelin [(1854) 1878, p. 73, plate 37, fig. 9], in the narrowing instead of widening of the glabella in front, in the presence of small instead of large eye-lobes, short instead of long postero-lateral limbs, and obscure glabellar furrows.

Pagodia bia Walcott.

Plate 15, Figures 10, 10*a*.

Pagodia bia Walcott, 1905, Proc. U. S. Nat. Mus., vol. xxix, p. 65. (Described as a new species essentially as below.)

Cephalon, exclusive of free cheeks, subrhomboidal, moderately convex. Glabella slightly convex, subquadrilateral in outline, slightly narrowed along the central portions, and marked by two pairs of short glabellar furrows on the posterior half and a very slight depression indicating a furrow on each side well toward the front; occipital furrow narrow, very clearly defined, and arching slightly forward toward the center; occipital ring narrow and rounded; dorsal furrow shallow but distinct.

Fixed cheeks about half as wide as the glabella and sloping gently downward from the dorsal furrow; palpebral lobes small, situated about midway between the front and back margins of the cephalon; no traces of palpebral ridges have been observed; postero-lateral limb short, strong, and marked by a rounded furrow within the posterior margin; frontal rim very narrow, rounded, and separated from the glabella and fixed cheeks by a narrow, deep furrow.

Surface marked by a few shallow, scattered punctæ, and under a very strong lens it appears to be minutely punctate.

The largest specimen of the cephalon in the collection has a length of 8 mm.

The form of the glabella of this species is not unlike that of *Pagodia macedo* [p. 163], but its anterior lobe is much broader.

Formation and Locality.—Upper Cambrian: (C56) Lower part of Ch'au-mi-tién limestone, 25 feet (7.5 m.) below the top of Pagoda Hill [Blackwelder, 1907*a*, p. 42 (part of last list of fossils)], 1 mile (1.6 km.) west of Tsi-nan, Shan-tung, China.

Collected by Eliot Blackwelder and Li San.

Pagodia dolon Walcott.

Plate 15, Figure 11.

Pagodia dolon Walcott, 1905, Proc. U. S. Nat. Mus., vol. xxix, p. 66. (Described as a new species essentially as below.)

This species is represented by two specimens of the cephalon, exclusive of the free cheeks. Glabella elongate, subquadrilateral, moderately convex; a very obscure trace of a posterior pair of short furrows is all that can be seen on the outer surface; occipital furrow rather narrow, clearly impressed, and arching slightly forward at the center; occipital ring narrow at the sides, increasing gradually in width to the center, where it is strong and moderately convex; dorsal furrow strong at the sides and front of the glabella.

Fixed cheeks a little more than one-half the width of the glabella, convex, and sloping outward and downward from the dorsal furrow; back of the palpebral lobes they slope gently to the furrow within the posterior margin, and anteriorly more rapidly to the furrow within the frontal rim; palpebral lobes small, about one-fourth the length of the cephalon; postero-lateral limb short, and marked by a strong,

rounded furrow within the narrow, slightly elevated posterior margin; frontal rim rounded, narrow, and separated from the glabella by a strong, rounded, rather deep furrow, which becomes more shallow in front of the fixed cheeks.

Surface marked by numerous, medium-sized punctæ, with very fine punctæ, visible only under a strong lens, between them.

The largest cephalon of the species has a length of 5.5 mm., with a width at the palpebral lobes of 8 mm.; the glabella has a length of 3 mm., with a width of 2.5 mm.

This species differs from the other species of the genus in its shorter, broader glabella, and more convex fixed cheeks.

Formation and Locality.—Upper Cambrian: (C41) Lower part of the Ch'au-mi-tién limestone [Blackwelder, 1907*a*, p. 36 (part of the first list of fossils)], 2.7 miles (4.3 km.) southwest of Ch'au-mi-tién, Shan-tung, China.

Collected by Eliot Blackwelder.

Pagodia lotos Walcott.

Plate 15, Figures 12, 12*a*.

Pagodia lotos WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 64. (Described and discussed as a new species essentially as below.)

Glabella moderately convex, elongate, with the sides converging very slightly toward the broadly rounded front; obscure traces of two pairs of furrows that extend a short distance inward and backward occur upon the sides; occipital furrow strong, rounded, and arching slightly forward at the center; occipital ring of medium width and rounded; dorsal furrow strong but shallow, and merging into the transverse furrow in front of the glabella.

Fixed cheeks about one-half the width of the cephalon opposite the palpebral lobes, slightly convex, and sloping gently posteriorly to the furrow within the margin, and anteriorly to the transverse furrow within the frontal rim; palpebral lobes small, short, not much more than one-fifth the length of the cephalon; a very slight trace of a palpebral ridge is shown upon the cast of the interior of the crust, but no evidences of it have been seen on the outer surface; frontal rim narrow, rounded so as to give it a thickened appearance, with a slightly flattened slope into the furrow back of it; it is separated from the glabella and fixed cheeks by a sharp furrow that almost cuts back under the front of the glabella.

The crust is thick; it appears to be smooth on the outer surface over the glabella and fixed cheeks, with the exception of scattered, shallow punctæ.

The type specimen has a length of 6 mm., with a width at the palpebral lobes of 8 mm.

The associated pygidium is convex, subsemicircular in outline, and strongly trilobed, except at the margin. Axial lobe convex, conical, and divided by three transverse furrows into three rings and a terminal, rounded, subtriangular portion. Pleural lobes nearly flat toward the front near the dorsal furrow, and from there curving abruptly downward toward the side and posterior margins; the furrows of the axis extend about two-thirds of the distance across the pleural lobes and merge, with the flat segments between them, into the margin; the margin slopes up from the sharp outer edge with a slight concavity where it merges into the pleural lobes and touches the posterior end of the axis.

This species differs from *Pagodia macedo* [p. 163] and *P. dolon* [p. 161] in its frontal rim and the slight convergence of the sides of its glabella toward the front. It is most nearly related to *Pagodia bia* [p. 161], with which it is associated. The latter species differs from *P. lotos* in its narrower and proportionately longer gla-

bella; the glabella of *P. bia* has a length of 6 mm. with a width at the center of 3 mm., while *P. lotos*, with a length of 5 mm., has a width at the center of nearly 4 mm.

Formation and Locality.—Upper Cambrian: (C56) Lower part of Ch'au-mi-tién limestone, 25 feet (7.5 m.) below the top of Pagoda Hill [Blackwelder, 1907*a*, p. 42 (part of last list of fossils)], 1 mile (1.6 km.) west of Tsi-nan, Shan-tung, China.

Collected by Eliot Blackwelder and Li San.

Pagodia macedo Walcott.

Plate 15, Figure 13.

Pagodia macedo Walcott, 1905, Proc. U. S. Nat. Mus., vol. xxix, p. 66. (Described as a new species.)

This species is represented by a single specimen of the cephalon, exclusive of the free cheeks. Glabella elongate, subquadrangular, narrowing very slightly toward the broadly rounded, nearly transverse front, as indicated by the cast of the interior of the crust; surface marked by two pairs of shallow furrows that penetrate a short distance on each side and separate the glabella into three subequal lobes; occipital furrow rounded and strong; occipital ring unknown; dorsal furrow strong, rounded, and clearly separating the moderately convex glabella from the sloping fixed cheeks.

Fixed cheeks slightly convex, sloping gently from the dorsal furrow to the palpebral lobe, more rapidly to the furrow within the posterior margin, and anteriorly to the front margin; palpebral lobes situated about midway between the front and the posterior margins of the cephalon, small and short, not much over one-fifth the length of the cephalon; frontal rim narrow, wire-like, and separated from the glabella and fixed cheeks by a rounded furrow of moderate depth.

The crust is rather thick, the outer surface marked by scattered, shallow punctæ, with very fine punctæ, as shown by a strong lens, between them.

Length of cephalon, exclusive of occipital ring, 7.5 mm.

This species is closely related to *Pagodia lotos* [p. 163]. It differs in the form of the frontal rim and the more uniform slope of the glabella toward the front. From *P. bia* [p. 161] it differs in the more rapid downward slope of the front of the glabella and in the parallel or slightly contracting sides of the glabella.

Formation and Locality.—Upper Cambrian: (C34) Purplish-gray limestone about 100 feet (30 m.) above the base of the Ch'au-mi-tién formation [Blackwelder, 1907*a*, p. 36 (part of first list of fossils)], in road at northeastern corner of small village near Ch'au-mi-tién, Shan-tung, China.

Collected by Eliot Blackwelder.

Genus LISANIA Walcott.

Lisania Walcott, 1911, Smithsonian Misc. Coll., vol. 57, No. 4, pp. 82–83. (Described and discussed as a new genus essentially as below.)

Cranidium subquadrate in outline, exclusive of postero-lateral limbs. Glabella with slightly converging sides, broadly rounded in front and curving gently down to a narrow furrow separating it from the frontal border, without distinctly marked glabellar furrows; occipital furrow distinct; occipital segment strong. Fixed cheeks narrow; palpebral lobe above the eye nearly one-third the length of the cephalon; palpebral ridge usually defined to the edge of the dorsal furrow beside the glabella. Frontal border slightly convex and separated from the fixed cheeks and glabella by a narrow, shallow, but distinct furrow.

The associated free cheeks have a strong genal spine, and associated pygidia a strong central axis marked by three or four transverse rings and a terminal section.

Surface smooth or slightly roughened by very fine shallow pits.

Genotype.—*Anomocarella (?) bura* Walcott [1905*b*, p. 56, and 1911, plate 15, fig. 2].

This genus is founded to receive four species that do not appear to fall within any described genus. From *Pagodia* [plate 15] it differs in having a longer eye-lobe, narrower free cheeks, and flatter frontal margin. *Pagodia* occurs with the Upper Cambrian fauna, *Lisania* with the Middle Cambrian fauna. From *Chuangia* [plates 16, 17] it differs in its narrower frontal border, narrower fixed cheeks, and quite unlike associated pygidium. The three genera, *Lisania*, *Pagodia*, and *Chuangia*, all have a strong, nearly smooth glabella and a narrow frontal margin and do not appear to come within the limits of *Agraulos*, *Anomocare*, *Ptychoparia*, *Coosia*, or *Solenopleura*.

The species referred to the genus are all small and unfortunately only represented by cranidia and associated free cheeks and pygidia. It may be that when entire specimens of the dorsal shield are found other marked differences will appear between the three genera, *Lisania*, *Pagodia*, and *Chuangia*.

The generic name is taken from Li San, the Chinese assistant of both Dr. Bailey Willis and Dr. Joseph P. Iddings.

The species referred to the genus *Lisania* are:

L. agonius (Walcott), Kiu-lung group, Middle Cambrian.
L. ajax (Walcott), Kiu-lung group, Middle Cambrian.
L. alala (Walcott), Ch'ang-hia limestone, Middle Cambrian.
L. ? belenus (Walcott), Ch'ang-hia limestone, Middle Cambrian.
L. bura (Walcott), Ch'ang-hia limestone, Middle Cambrian.
L. cf. *bura* (Walcott), Ch'ang-hia limestone, Middle Cambrian.

Lisania agonius (Walcott).

Plate 15, Figures 17, 17*a*.

Arionellus agonius Walcott, 1905, Proc. U. S. Nat. Mus., vol. xxix, p. 58. (Species described essentially as below.)

Central portion of the cephalon, exclusive of the free cheeks, irregularly subquadrilateral, convex. Glabella moderately convex, narrowing slightly toward the front; length and width at the base nearly the same; by reflected light traces of two pairs of glabellar furrows may be seen; occipital furrow narrow and shallow; occipital ring narrow at the sides, becoming stronger toward the center, which rises to form the base of a short, strong, backward-sloping spine; dorsal furrow narrow and clearly defined.

Fixed cheeks narrow and nearly flat at the palpebral lobes; they slope rapidly in front toward the frontal margin, and backward toward the postero-lateral limb; palpebral lobes narrow, about one-third the length of the cephalon; frontal limb narrow directly in front of the glabella and rounding over to the rounded frontal rim.

Surface smooth under a strong lens.

The type specimen of the cephalon has a length of 4 mm., with a slightly greater width at the palpebral lobes.

This species differs from *Lisania alala* [p. 165] in having a thickened rounded frontal rim and a proportionately wider glabella. From *Lisania ajax* [p. 165] it differs in being broader and in the presence of an occipital spine.

Formation and Locality.—Middle Cambrian: (C 1 and C 2) Lower shale member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 40 (part of the third list of fossils), and fig. 10 (beds 4 and 5), p. 38), 2 miles (3.2 km.) south of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Collected by Eliot Blackwelder.

Lisania ajax (Walcott).

Plate 15, Figures 18, 18*a*.

Arionellus ajax WALCOTT, 1905, Proc. U.S. Nat. Mus., vol. XXIX, p. 58. (Species described essentially as below.)

Cephalon, exclusive of free cheeks, subrhomboidal in outline, convex. Glabella moderately and uniformly convex, sides converging very slightly from the base to the rounded front; slight traces of short furrows are shown by reflected light; occipital furrow a faint, transverse depression that separates the glabella from a fairly strong, slightly convex occipital ring; dorsal furrow narrow but clearly defined.

Fixed cheeks very narrow and sloping away from the glabella toward the palpebral lobes; posteriorly they slope forward into a rather large postero-lateral limb; anteriorly they slope rapidly to the frontal limb; palpebral lobes prominent, about one-fourth the length of the cephalon; frontal limb gently convex, rounded in front, and without traces of a frontal rim.

Surface smooth under a strong lens.

The type specimen of the cephalon has a length of 4 mm.

In form the cephalon of this species is somewhat like that of *Lisania alala* (Walcott). It differs in the absence of an occipital spine and in being proportionately somewhat narrower.

Formation and Locality.—Middle Cambrian: (C12) Gray limestone near the top of the middle limestone member of the Kiu-lung group [Blackwelder 1907*a*, pp. 37 and 41 (part of the first list), and fig. 10 (bed 7), p. 38], 3.25 miles (5.2 km.) southwest of Yen-chuang, and (C40), limestone nodules in green shales in the middle limestone member of the Kiu-lung group [idem (part of the first list of fossils)], in a gully in bank of river 2 miles (3.2 km.) south of Yen-chuang, Sin-t'ai district, Shantung, China.

Collected by Eliot Blackwelder and Li San.

Lisania alala (Walcott).

Plate 15, Figures 19, 19*a–d*.

Arionellus alala WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 59. (Species characterized as below.)

In general form and proportion the central parts of the cephalon of this species are much like *Lisania agonius* [p. 164]. They differ in the proportionately smaller elongate glabella, nearly flat frontal limb, and a thin instead of a rounded margin.

Formation and Locality.—Middle Cambrian: (C51) Lower part of gray crystalline limestone in the upper portion of the oolitic part of the Ch'ang-hia limestone [Blackwelder, 1907*a*, p. 33 (part of the first list of fossils)], at Ch'au-mi-tién, Shantung, China.

Collected by Eliot Blackwelder.

A somewhat similar and possibly identical form occurs at about the same horizon (C4), limestone nodules at the base of the lower shale member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 40 (second list of fossils), and fig. 10 (bed 4), p. 38], 3 miles (4.8 km.) southwest of Yen-chuang, Sin-t'ai district, Shantung; also (C22), Ch'ang-hia limestone in upper oolitic portion [idem, pp. 22 and 33 (part of last list of fossils)], at Ch'ang-hia, Shan-tung, and (C30) layer in black oolite of the Ch'ang-hia limestone [idem, p. 33, part of first list of fossils], 25 feet (7.5 m.) above the second cliff, at an elevation of 1,700 feet (568.9 m.) on top of the long north and south ridge at Ch'ang-hia, Shan-tung; also (C46), light gray, crystal-

line limestone in the Ch'ang-hia limestone [Blackwelder, 1907*a*, p. 33, fourth list of fossils], at Ch'au-mi-tién, Shan-tung, China.

Collected by Eliot Blackwelder.

Lisania ? belenus (Walcott).

Plate 15, Figure 16.

Menocephalus belenus WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 62. (Species discussed from fragment of the cephalon.)

This species is represented by a single specimen of a glabella, occipital ring, and frontal rim. It differs from *L. bura* [plate 15, fig. 15] in having a very narrow, slightly flattened frontal rim and a very finely pustulose surface. The glabella is also more conical and its front more rounded. A fragment of the fixed cheeks indicates that they were rather convex and rose somewhat abruptly from a distinct dorsal furrow.

Formation and Locality.—Middle Cambrian: (C19) Uppermost layers of the Ch'ang-hia limestone [Blackwelder, 1907*a*, p. 33 (part of last list of fossils)], at Ch'ang hia, Shan-tung, China.

Collected by Li San.

Lisania bura (Walcott).

Plate 15, Figures 14, 15.

Anomocarella ? bura WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 56. (Species described as below.)

Anomocarella bura WALCOTT, 1911, Smithsonian Misc. Coll., vol. 57, No. 4, p. 82, pl. 15, fig. 2. (Referred and figured as genotype of new genus *Lisania*.)

This species is represented by the central portions of a single cephalon. Glabella convex, subquadrilateral, arching very gently from the occipital ring forward, and near the front rather more rapidly downward to the furrow within the frontal rim; without traces of glabellar furrows; occipital furrow narrow, clearly defined; occipital ring rather wide, slightly convex, and projecting a little backward at the center; dorsal furrow shallow, narrow, but clearly defined.

Fixed cheeks about one-fourth the width of the glabella; palpebral lobe more than one-third the length of the cephalon, with a relatively broad outer rim, outlined by a very narrow, faintly defined furrow; palpebral ridge short, broad, low, and merging into the palpebral lobe; postero-lateral limb short; frontal rim slightly rounded, separated from the glabella and fixed cheeks by a narrow furrow.

Surface apparently smooth, but with a few scattered, very fine punctæ as seen with a strong lens.

The type and only specimen of the cephalon has a length of 3 mm.

Formation and Locality.—Middle Cambrian: (C22) Ch'ang-hia limestone, in upper oolite portion [Blackwelder, 1907*a*, pp. 22 and 33 (part of last list of fossils)], at Ch'ang-hia, Shan-tung, China.

Collected by Eliot Blackwelder.

A form compared with this species occurs in association with *Anomocarella irma* Walcott [p. 202]. The cranidium does not appear to have the strong palpebral ridge reaching the furrow beside the glabella, as in *Lisania bura*, but in most characters it is quite similar. With only one broken cranidium of each form I do not think it best to identify them as belonging to the one species or to separate them as distinct species.

Formation and Locality.—Middle Cambrian: (C77) Limestone interbedded in green shales not more than 300 feet (90 m.) above the Man-t'o shales [Willis and Blackwelder, 1907, p. 144 (first list of fossils)], 4 miles (6.4 km.) southeast of Yau-t'o, near Wu-t'ai-hién, Shan-si, China.

Collected by Eliot Blackwelder.

Lisania spp. undt. (*a*), (*b*).

Plate 15, Figures 20, 21.

Two pygidia are illustrated by figures 20 and 21 that may belong to this genus.

The specimen represented by figure 20 is from Locality C30, Middle Cambrian, layer in black oolite of the Ch'ang-hia limestone [Blackwelder, 1907*a*, p. 33 (part of first list of fossils)], 25 feet (7.5 m.) above the second cliff at an elevation of 1,700 feet (568.9 m.) on top of the long north and south ridge at Ch'ang-hia, Shan-tung, China.

That represented by figure 21 is from Locality C41, Upper Cambrian, lower part of the Ch'au-mi-tién limestone [Blackwelder, 1907*a*, p. 36 (part of the first list of fossils)], 2.7 miles (4.3 km.) southwest of Ch'au-mi-tién, Shan-tung, China.

Collected by Eliot Blackwelder.

Genus SOLENOPLEURA Angelin.

Solenopleura ANGELIN, 1854 (edition 1878), Pal. Scandinavica, pt. 1, p. 26. (Described as a new genus.)

For the purposes of comparison three views are given on plate 17, figures 12, 12*a*–*b*, of a cranidium of *Solenopleura holometopa* Angelin [1854 (ed. 1878), p. 26, plate 18, figs. 8, 8*a*] obtained by photographing a specimen from the type locality at Andrarum. The strongly tuberculated surface is shown by figure 12*c*, a photograph of an associated free cheek.

Solenopleura agno Walcott.

Plate 17, Figure 15.

Solenopleura agno WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 89. (Described as a new species essentially as below.)

General form of cephalon, exclusive of free cheeks, transversely subrhomboidal, convex. Glabella as long as the width at its base, the sides converging from the base toward the rounded front, so as to narrow the glabella about one-fourth; a very slight trace of a short, posterior pair of furrows can be seen by reflected light; occipital furrow well defined by the downward curvature of the posterior margin of the glabella and rising of the surface of the occipital ring; the latter is narrow at the sides, gradually widening toward the center, which is most elevated a little in front of the posterior margin; dorsal furrow narrow, but clearly defined at the sides in front of the glabella.

Fixed cheeks about one-half the width of the glabella at the center, rather convex, and sloping somewhat abruptly to the frontal rim; palpebral lobe small, situated about midway of the cheeks; postero-lateral limbs unknown; frontal limb very narrow in front of the glabella, convex, and curving down to the broad groove within the strong, rounded frontal rim.

Surface marked by low pustules that give it a roughened appearance.

The type and only specimen of the cephalon in the collection has a length of 6 mm.

This species is characterized by its broad, short glabella, narrow frontal limb, and peculiar, granulose surface.

A cephalon referred to this species occurs at Ch'au-mi-tién at a lower horizon in the Ch'ang-hia limestone, and appears to be identical with the type specimen, except that the granulation of the surface is finer and the granules are more scattered.

Formation and Locality.—Middle Cambrian: (C25) Limestone about 50 feet (15 m.) below the Ku-shan shale in the uppermost beds of the Ch'ang-hia formation [Blackwelder, 1907*a*, p. 33 (part of the last list of fossils)], at Ch'ang-hia, Shan-tung; also (C51), lower part of gray crystalline limestone in the upper portion of the oolitic part of the Ch'ang-hia limestone [idem (part of the first list of fossils)], at Ch'au-mi-tién, Shan-tung, China.

Collected by Eliot Blackwelder.

Also from Locality 35r, Fu-chóu series; limestones near the base of the series just above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general section giving stratigraphic relations], collected in a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria, China.

Collected by J. P. Iddings and Li San.

Solenopleura beroe Walcott.

Plate 17, Figures 14, 14*a*, 17.

Solenopleura beroe WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 91. (Species characterized as below.)

The description of the general form of the cephalon of *S. agno* [p. 167] applies very closely to this species. It differs from the latter in its broader fixed cheeks, shorter frontal limb, more clearly marked glabellar furrows, and minutely pustulose surface. The type and only specimen of the cephalon in the collection has a length of 4 mm. A number of specimens of the cephalon of this species were collected by Dr. J. P. Iddings in Manchuria in association with the *Dorypyge richthofeni* fauna.

Formation and Locality.—Upper Cambrian: (C64) Upper limestone member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 42 (first list of fossils), and fig. 10 (bed 20), p. 38], 2.7 miles (4.3 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Collected by Eliot Blackwelder.

Also from Locality 35n, Middle Cambrian: Fu-chóu series; limestones near the base of the series just above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general section giving stratigraphic relations]; collected in a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria, China

Collected by J. P. Iddings and Li San.

Solenopleura chalcon Walcott.

Plate 17, Figure 13.

Solenopleura chalcon WALCOTT, 1911, Smithsonian Misc. Coll., vol. 57, No. 4, p. 83, plate 16, fig. 5, (Described and discussed as a new species essentially as below.)

Only one specimen of the cranidium of this species is known. In form it is nearest to *Solenopleura beroe* Walcott [plate 17, fig. 14]. It differs in having a proportionately narrower glabella; more convex free cheeks; more rounded frontal rim, and in the presence of a depression dividing the frontal limb on the median line of the glabella. Its tuberculated surface is much like that of *S. beroe.*

Formation and Locality.—Middle Cambrian: (35r) Fu-chóu series, limestones near the base just above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general section giving stratigraphic relations]; collected in a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria, China.

Collected by J. P. Iddings and Li San.

Solenopleura intermedia (Walcott).

Plate 17, Figures 16, 16*a*.

Ptychoparia (*Liostracus*) *intermedia* WALCOTT, 1906, Proc. U.S.Nat. Mus., vol. XXX, p. 592. (Species compared with other species of *Ptychoparia* and subgenus *Liostracus*.)

This species is represented by a single well-preserved specimen of the central portions of the cephalon. It differs in details from *S. agno* [plate 17, fig. 15,] and *S. beroe* [plate 17, figs. 14, 14*a*, 17], as may be seen by comparing the figures.

The surface of *S. intermedia* is marked by a few scattered, rather large tubercles and many very fine tubercles. A cephalon 8 mm. in length has a width at the outer edge of the palpebral lobes of 9 mm., with a convexity of 2 mm. above the plane of the margin of the cephalon.

Formation and Locality.—Middle Cambrian: (C51) Lower part of gray crystalline limestone in the upper portion of the oolitic part of the Ch'ang-hia limestone [Blackwelder, 1907*a*, p. 33 (part of the first list of fossils)], at Ch'au-mi-tién, Shantung, China.

Collected by Eliot Blackwelder.

Solenopleura pauperata Walcott.

Plate 17, Figure 18.

Solenopleura pauperata WALCOTT, 1906, Proc. U. S. Nat. Mus., vol. XXX, p. 593. (Described as a new species essentially as below.)

This species is represented by the central portions of the cephalon, exclusive of the free cheeks and the occipital ring. The portions preserved show that the cephalon was semicircular and rather strongly convex. Glabella truncato-conical, rounded in front, strongly convex, and marked by three pairs of very short, slightly impressed furrows; the fragment of the occipital furrow remaining shows it to have been narrow and rather deep; occipital ring unknown; dorsal furrow narrow and rather deep at the sides, and clearly defined in front of the glabella.

Fixed cheeks about two-thirds the width of the glabella, convex, and curving gently to the front and back; palpebral lobes central and small; no traces of palpebral ridges; postero-lateral limb about as long as the width of the glabella, and marked by a sharply impressed furrow within a narrow, rounded posterior rim; the line of demarcation between the front of the glabella and the frontal rim is a rather deep, narrow furrow, no traces of a frontal limb being present; frontal rim strong, rounded, and broadly curved in front.

Surface minutely granular, with a few larger granules scattered over the surface of the glabella, and a number of slightly larger granules scattered over the surface of the fixed cheeks. The type and only specimen of the cephalon has a length of 3 mm., exclusive of the occipital ring.

This species is characterized by the absence of a frontal limb, and its broadly conical glabella, in these respects differing from *Solenopleura agno* [plate 17, fig. 15] and *S. beroe* [plate 17, fig. 14]. It also differs from the two mentioned species by having a more finely granulated surface.

Formation and Locality.—Middle Cambrian: (C71) Massive cliff-making limestone in the central portion of the Ki-chóu formation [Willis and Blackwelder, 1907, pp. 139 and 145 (second list of fossils)], 4 miles (6.4 km.) southwest of Tung-yü, Shan-si, China.

Collected by Bailey Willis and Eliot Blackwelder.

Solenopleura sp. undt.

Fragments of the cephalon of a large, strongly tuberculated species resembling *Menocephalus abderus* (Walcott) and *M. acanthus* Walcott [plate 16] occur with *Dorypyge richthofeni* fauna in Manchuria. The glabella is not so convex or so strongly tuberculated as in those species. Until better material is available the species is referred to *Solenopleura* as an undetermined species.

Formation and Locality.—Middle Cambrian: (35n) Fu-chóu series, limestones near base of series just above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general section giving stratigraphic relations], collected in a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria, China.

Collected by J. P. Iddings and Li San.

Genus CHUANGIA Walcott.

Chuangia Walcott, 1911, Smithsonian Misc. Coll., vol. 57, No. 4, pp. 83–84. (Described and discussed as a new genus essentially as below.)

This genus is proposed for a group of Upper Cambrian trilobites in which the cephalon has a truncato-conical or subquadrangular glabella; a narrow, concave frontal limb, and, as far as known, a smooth test.

The associated pygidium is large, with a strong axis, broad pleural lobes, and few indications of segments.

The general form of the glabella is much like that of some species of *Anomocare* [see plate 18], but the frontal limb is quite different. The latter suggests *Pagodia lotos* Walcott [plate 15, fig. 12], but the frontal limb of the latter is absorbed by the rounded frontal rim. In *Chuangia* the frontal limb and rim meet to form an angle and the rim does not rise above the upward sloping surface of the frontal limb.

Genotype.—*Ptychoparia ? batia* Walcott [1905*b*, Proc. U. S. Nat. Mus., vol. xxix, p. 75, and Walcott, 1911, plate 15, figs. 3, 3*a*]. Three other species known from the Upper Cambrian formations of China: *Chuangia nitida*, *C. nais*, and *C. fragmenta*.

Chuangia batia (Walcott).

Plate 17, Figures 20, 20*a–d*.

Ptychoparia ? batia Walcott, 1905, Proc. U. S. Nat. Mus., vol. xxix, p. 75. (Species described essentially as below.)

Chuangia batia (Walcott), 1911, Smithsonian Misc. Coll., vol. 57, No. 4, p. 84, pl. 15, figs. 3, 3*a*. (Referred and figured as genotype of new genus *Chuangia*.)

Cephalon, exclusive of the free cheeks, subrhomboidal, moderately convex. Glabella truncato-conical; a specimen with a length of 11 mm. has a width at the base of 11 mm., and at the broadly rounded, almost transverse front, of 7 mm.; very faint traces are shown of a posterior pair of furrows; occipital furrow nearly straight, shallow, rounded, and narrow; occipital ring strong, very slightly convex, and slightly wider at the center than at the ends; it is marked at the center, near the occipital furrow, by a minute node; dorsal furrow distinctly but not deeply marked.

Fixed cheeks wide and slightly convex, nearly flat between the glabella and palpebral lobe, and curved downward in front to the frontal rim and backward to the furrow within the posterior margin; palpebral ridge narrow and low, but distinctly shown; posteriorly it passes into the palpebral lobe; palpebral lobe small, and situated a little back of a transverse line drawn through the center of the cephalon; postero-lateral limb large, about as long as the base of the glabella is wide, and marked by a strong furrow within the elevated posterior margin. The front of the glabella and of the fixed cheeks curves down into a shallow furrow, from which the frontal rim rises before curving over to form a thick frontal margin, which is marked by longitudinal, raised striæ.

Surface smooth under a strong lens.

The largest of three specimens of a cephalon has a length of 20 mm., with a width at the palpebral lobes of 26 mm.

This species is characterized by its large size, concave frontal rim, and nearly smooth glabella. A somewhat similar cephalon occurs in the upper portion of the Ch'au-mi-tién limestone, at about the same horizon, 9 miles (14.4 km.) north of Sin-t'ai-hién.

Formation and Locality.—Upper Cambrian: (C64) Upper limestone member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 42 (first list of fossils), and fig. 10 (bed 20), p. 38], 2.7 miles (4.3 km.) southwest of Yen-chuang; (C61), a dense black limestone in the uppermost limestone member of the Kiu-lung group [idem, pp. 37 and 41 (third list of fossils), and fig. 10 (bed 13), p. 38], 3 miles (4.8 km.) southwest of Yen-chuang, Shan-tung; and (C11), crystalline limestone 60 feet (18 m.) above the base of the uppermost limestone member [idem, pp. 37 and 41 (last list of fossils)], 2.1 miles (3.4 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung; also (C33*a*), talus near the base of the cliff of Ch'au-mi-tién limestone [idem, p. 41 (part of last list of fossils)], 9 miles (14.4 km.) north of Sin-t'ai-hién, Shan-tung, China.

Collected by Eliot Blackwelder and Li San.

A form apparently identical was found by Mr. Blackwelder in limestone blocks in talus at (C44), 200 feet (60 m.) above the top of the section containing C46, C48, and C51, at Ch'au-mi-tién, Ch'ang-hia district, Shan-tung, China.

Chuangia fragmenta Walcott.

Plate 16, Figure 2.

Chuangia fragmenta WALCOTT, 1911, Smithsonian Misc. Coll., vol. 57, No. 4, p. 84, plate 15, fig. 4. (Described and discussed as a new species essentially as below.)

Only a fragment of the cephalon of this species is known. This suggests the glabella of *Chuangia batia*, but the narrow fixed cheeks serve to distinguish it. The surface is smooth to the unaided eye, and slightly pitted or punctate under a strong lens. The fragment of the cephalon has a length of 16 mm.

Formation and Locality.—Upper Cambrian: (C61) A dense black limestone in the uppermost limestone member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 41 (third list of fossils), and fig. 10 (bed 13), p. 38], 3 miles (4.8 km.) southwest of Yen-chuang, Shan-tung, China.

Collected by Li San.

Chuangia nais Walcott.

Plate 16, Figure 1.

Chuangia nais WALCOTT, 1911, Smithsonian Misc. Coll., vol. 57, No. 4, pp. 84–85, plate 15, fig. 6. (Described and discussed as a new species essentially as below.)

This is a large species that is represented by a part of the central portions of the cephalon. Glabella subquadrangular, moderately convex, narrowing slightly toward its broadly rounded front; without glabellar furrows as far as can be determined; occipital furrow shallow, rather broad, and nearly transverse; occipital ring gently convex, and slightly wider toward the center; dorsal furrow shallow and clearly defined.

Fixed cheeks about two-thirds the width of the glabella, nearly flat between the glabella and the palpebral lobes, and sloping downward in front to the frontal rim, and back to the posterior furrow; palpebral lobe small; palpebral ridge narrow, low, and situated so as to cross the fixed cheek obliquely where the downward slope to the front is most marked; postero-lateral limb long, with a strong furrow within

the strong rounded rim; the front of the glabella passes into the broad groove that merges into the upward-sloping, narrow frontal limb; frontal rim rounded and marked by rather strong striæ parallel to the frontal border.

Surface smooth to the unaided eye; a strong lens shows a slight, irregular pitting where the outer surface is intact. The type specimen of the cephalon has a length of 20 mm.

This species was at first confused with *Chuangia batia*. It differs from the latter in the form of the glabella and the size of the palpebral lobes and frontal limb. The same features distinguish it from *Chuangia nitida* and *C. fragmenta*.

Formation and Locality.—Upper Cambrian: (C64) Upper limestone member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 42 (first list of fossils), and fig. 10 (bed 20), p. 38], 2.7 miles (4.3 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Collected by Eliot Blackwelder.

Chuangia nitida Walcott.

Plate 17, Figure 21.

Chuangia nitida WALCOTT, 1911, Smithsonian Misc. Coll., vol. 57, No. 4, pp. 85–86, plate 15, fig. 6. (Described and discussed as a new species essentially as below.)

Only the central portions of the moderately convex cephalon are known of this species. Within the facial sutures the outline is subquadrangular, exclusive of the short postero-lateral limb. Glabella slightly convex, truncato-conical, with a very slight trace of short, slightly oblique posterior glabellar furrows; the latter are shown more distinctly on the cast of the interior; occipital furrow shallow and clearly defined; occipital ring slightly convex and rather broad toward the center; dorsal furrow shallow at the sides of the glabella.

Fixed cheeks about one-half the width of the glabella, gently convex; palpebral ridges strong, low, and passing obliquely backward to the rim of a rather large palpebral lobe; the latter is a little longer than one-third the length of the cephalon. The frontal limb is represented by the short concave space in front of the glabella, which forms a sharp angle in uniting with the frontal limb.

Surface slightly pitted when seen through a strong magnifying glass. Length of cephalon, 7 mm.

This species is much smaller than the type species, *Chuangia batia* [p. 170]. It differs from the latter in its narrower frontal limb, larger palpebral lobes, and more elongate glabella. From *Chuangia nais* and *C. fragmenta* [p. 171] it differs in its longer palpebral lobes and outline of the glabella.

Formation and Locality.—Upper Cambrian: (C11) Crystalline limestone 60 feet (18 m.) above the base of the uppermost limestone member [Blackwelder, 1907*a*, pp. 37 and 41 (last list of fossils)], 2.1 miles (3.4 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Collected by Eliot Blackwelder.

Genus MENOCEPHALUS Owen.

Menocephalus OWEN, 1852, Geol. Surv. Wisconsin, Iowa, and Minnesota, p. 577, plate 1, fig. 11.

Doctor Owen proposed this genus for trilobites having a highly convex, hemisperical glabella, with a narrow border and a broadly rounded front; cheeks tumid, surface pustulate.

The genotype of *Menocephalus* was destroyed by fire many years ago. A careful study of a large collection of specimens from the type locality at Minneiska in

connection with the illustration given by Doctor Owen leads me to think that the genotype was a fragment of the cranidium of Owen's *Dikelocephalus granulosus*, illustrated by figure 7, plate 1 [Owen, 1852]. This, however, can not be proven, so I will accept Owen's definition and include under the genus a group of species having a strongly convex glabella, with a narrow frontal limb and border and broadly rounded front; tumid fixed cheeks, small eye-lobes, granulated surface, and very faint or no glabellar furrows.

The species are more or less provisionally referred, as only the central portions of the cephalon are preserved. Further study, or the study of more perfect specimens, will undoubtedly lead to the reference of some of them to other genera.

Neither of the species referred to *Menocephalus* by E. Billings appears to belong to the genus. They are:

Menocephalus sedgwicki Billings [1865*b*, p. 407] = *Solenopleura;*
Menocephalus glabosus Billings [1865*b*, p. 408] = *Solenopleura.*

Menocephalus salteri Devine [Billings, 1865*a*, p. 203] is the type, an undescribed genus.

Menocephalus abderus (Walcott).

Plate 16, Figure 3.

Solenopleura abderus WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 88. (Species characterized as below.)

This species is represented by the glabella, occipital ring, fixed cheek, and frontal rim. It is most closely related to *M. acanthus*, but differs in the narrower fixed cheeks and short, rounded frontal rim. The surface is also marked by larger and many more pustules, which are scattered more or less irregularly over the surface. Three pairs of short glabellar curves are faintly indicated upon the rounded sides of the somewhat convex glabella. The type specimen has a length of 8 mm. and a large cephalon associated with it of 12.5 mm.

Formation and Locality.—Middle Cambrian: (C19) Uppermost layers of the Ch'ang-hia limestone [Blackwelder, 1907*a*, p. 33 (part of last list of fossils)], at Ch'ang-hia, Shan-tung, China.

Collected by Li San.

Menocephalus acanthus (Walcott).

Plate 16, Figures 4, 4*a–b*.

Solenopleura acantha WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 88. (Species described as below.)

General form of cephalon, exclusive of free cheeks, transversely rhomboidal, and rather convex. Glabella prominent, convex, truncato-conical, with width at the base and length about the same; a short, strong furrow marks off two small, subtriangular lobes at the postero-lateral angle; a second pair of slightly marked furrows occurs upon the sides, next to the dorsal furrow, about midway of the length of the glabella; the sides slope inward from the base, so as to reduce the width of the rounded front to about two-thirds that of the base; occipital furrow narrow, transverse, and deep; occipital ring narrow at the sides, broadening toward the center, where it is thick and convex; dorsal furrow very distinct at the sides and front.

Fixed cheeks convex, but much lower than the glabella; they are about as wide at the palpebral lobe as the width of the glabella in front; their appearance of convexity is given by the downward slope toward the frontal rim and backward

to the furrow just within the posterior margin; palpebral lobe small, situated about midway of the fixed cheek; no traces of palpebral ridges are shown; a strong, slightly rounded frontal rim is separated from the glabella and fixed cheeks by a narrow, rounded, transverse furrow; postero-lateral limb short, and marked by a narrow, deep furrow just within the raised posterior margin.

Surface marked by strong pustules in all parts with the exception of the dorsal furrow and furrow back of the frontal rim.

In general form this species resembles *Solenopleura agno* [p. 167] and *Menocephalus abderus* [p. 173]. It differs from the former in the shape and convexity of the glabella and broader fixed cheeks, and from the latter in the shape of its glabella, fixed cheeks, and frontal rim.

Formation and Locality.—Middle Cambrian: (C22) Ch'ang-hia limestone, in upper oolitic portion [Blackwelder, 1907*a*, pp. 22 and 33 (part of last list of fossils)], at Ch'ang-hia, Shan-tung, China.

Collected by Eliot Blackwelder.

Menocephalus acerius Walcott.

Plate 16, Figures 10, 10*a*.

Menocephalus acerius WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 60. (Species described as below.)

This species is represented by a single specimen of the glabella, fixed cheek, and frontal limb. The glabella is moderately convex, broadly truncato-conical in outline, and marked by two pairs of faintly impressed, short furrows; the sides approach each other slightly toward the broadly rounded front; occipital furrow rounded and distinct; occipital ring moderately convex and a little wider than the occipital furrow; dorsal furrow well defined.

Fixed cheeks convex, about two-thirds the width of the glabella; they slope rather rapidly downward to the frontal rim and less so to the postero-lateral limb; palpebral ridge not distinctly defined; palpebral lobes small; frontal rim separated from the glabella and fixed cheeks by a strong, narrow furrow; the rim is rounded and of about the same width as the occipital ring.

Surface covered with pustules perceptible to the unaided eye.

The cephalon of the type specimen has a length of 10 mm.; the frontal rim and occipital ring are each about 1 mm. in width.

This species is referred to the genus *Menocephalus* on account of the small palpebral lobes, pustulose surface, and the absence of a frontal limb. It differs from the type form in having a less convex, more elongated glabella.

Formation and Locality.—Middle Cambrian: (C18) Dark gray oolitic limestone about 400 feet (120 m.) above the base of the Ch'ang-hia limestone [Blackwelder, 1907*a*, p. 33 (third list of fossils)], in cliffs 1 mile (1.6 km.) east of Ch'ang-hia, Shan-tung, China.

Collected by Eliot Blackwelder.

Menocephalus acidalia (Walcott).

Plate 16, Figures 8, 8*a*.

Solenopleura acidalia WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 89. (Species described essentially as below.)

The description of *M. acanthus* [p. 173] applies to this species, except that it does not have so short a frontal limb as the latter, and its frontal rim is nearly flat instead of rounded. The surface is smooth, with the exception of a few large, low,

scattered pustules. The cephalon of the type and only specimen in the collection has a length of 4 mm.

Formation and Locality.—Middle Cambrian: (C30) Layer in black oolite of the Ch'ang-hia limestone [Blackwelder, 1907*a*, p. 33 (part of first list of fossils)], 25 feet (7.5 m.) above the second cliff at an elevation of 1,700 feet (568.9 m.) on top of the long north and south ridge at Ch'ang-hia, Shan-tung, China.

Collected by Eliot Blackwelder.

Menocephalus acis Walcott.

Plate 16, Figure 11.

Menocephalus acis WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 60. (Species described as below.)

Glabella prominent, convex, narrowing slightly from its base toward the broadly rounded front; occipital furrow narrow, deep, and separating a rather strong, rounded occipital ring; dorsal furrow narrow and strongly defined.

Fixed cheeks about one-half the width of the glabella, moderately convex to the base of the palpebral lobe; posteriorly they slope rapidly to the furrow within the posterior margin, anteriorly rapidly to the frontal rim; palpebral lobe small and somewhat elevated; frontal rim narrow, rounded, and separated from the glabella by the narrow dorsal furrow.

Surface marked by rather strong, scattered granules.

The only specimen representing this species has a length of 5 mm.

This species is characterized by its narrow, wire-like frontal rim and the scattered granules on its outer surface.

Formation and Locality.—Middle Cambrian: (C35) Upper part of the Ch'ang-hia limestone [Blackwelder, 1907*a*, p. 33, fifth paragraph], at Ch'au-mi-tién, Shan-tung, China.

Collected by Eliot Blackwelder.

Menocephalus admeta Walcott.

Plate 16, Figure 12.

Menocephalus admeta WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 61. (Described as a new species as below.)

Glabella strongly convex, with subparallel sides and rounded front; occipital furrow narrow and deep; occipital ring narrow at the sides, increasing in width toward the center, slightly convex, rising with a backward slope from the bottom of the occipital groove; dorsal furrow narrow and strongly defined.

Fixed cheeks about two-thirds of the width of the glabella, slightly convex opposite the palpebral lobe, and sloping downward to a strong furrow within the rounded rim of the short postero-lateral limb; frontal rim narrow and slightly rounded.

Surface with minute tubercles under a strong lens.

The only cephalon of this species in the collection has a length of less than 2 mm.

This species is distinguished from *M. acis* by the form of the convex glabella and flattened instead of wire-like frontal rim. It does not appear to be closely related to any other species.

Formation and Locality.—Middle Cambrian: (C22) Ch'ang-hia limestone, in upper oolitic portion [Blackwelder, 1907*a*, pp. 22 and 33 (part of last list of fossils)], at Ch'ang-hia, Shan-tung, China.

Collected by Eliot Blackwelder.

Menocephalus agave Walcott.

Plate 16, Figure 9.

Menocephalus agave WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 62. (Characterized as a new species as below.)

Another species of *Menocephalus* is associated with *Levisia adrastia* [p. 177], in which only the anterior portions of the cephalon and one fixed cheek are preserved. This differs from *L. adrastia* in the proportionately narrower glabella, rounded frontal rim, and less convex fixed cheek. Its surface is very finely pustulose, with scattered larger pustules on the glabella. The palpebral lobe is very small and situated a little back of the center of the cephalon.

Formation and Locality.—Middle Cambrian: (C30) Layer in black oolite of the Ch'ang-hia limestone [Blackwelder, 1907*a*, p. 33 (part of first list of fossils)], 25 feet (7.5 m.) above the second cliff at an elevation of 1,700 feet (568.9 m.) on top of the long north and south ridge at Ch'ang-hia, Shan-tung, China.

Collected by Eliot Blackwelder.

Menocephalus ? depressus Walcott.

Plate 16, Figures 6, 6*a*.

Menocephalus ? depressus WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 62. (Described as a new species as below.)

General form of the cephalon, exclusive of the free cheeks, subrhomboidal, moderately convex. Glabella moderately convex, narrowing slightly from the base toward the rather broadly rounded front; surface marked by two pairs of very shallow, short glabellar furrows; occipital furrow narrow, transverse, and sharply impressed; occipital ring slightly convex and of nearly uniform width; dorsal furrow narrow and sharply defined.

Fixed cheeks about one-half the width of the glabella, convex, arching with about the same slope to the palpebral lobe from the front and back; palpebral lobe small, situated about midway of the cheek; no evidence of the presence of a palpebral ridge; postero-lateral limb short, marked by a distinct groove parallel to the narrow, elevated posterior margin; frontal rim narrow, convex, and separated from the glabella and fixed cheeks by a distinct, narrow groove.

Surface with numerous low, medium-sized, scattered pustules.

The type and only specimen of the cephalon in the collection has a length of 4.5 mm.

This species is doubtfully referred to the genus *Menocephalus*. It is most nearly related to *M. acis*, but differs in having a less convex glabella and narrower fixed cheeks.

Formation and Locality.—Upper Cambrian: (C56) Lower part of Ch'au-mi-tién limestone, 25 feet (7.5 m.) below the top of Pagoda Hill [Blackwelder, 1907*a*, p. 42 (part of last list of fossils)], 1 mile (1.6 km.) west of Tsi-nan, Shan-tung, and (C49), purplish-brown limestone in the lower part of the Ch'au-mi-tién limestone [idem, p. 36 (part of first list of fossils)], in roadway 2.5 miles (4 km.) west-southwest of Ch'au-mi-tién, Shan-tung, China.

Collected by Eliot Blackwelder and Li San.

Menocephalus ? sp. undt. Walcott.

Plate 16, Figures 7, 7*a*.

Menocephalus sp. undt. WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 63. (Species described as below.)

This form is represented by the anterior half of the glabella and fixed cheeks. These parts indicate that the glabella was strongly convex, rounded in front, and

marked by two pairs of very slight, short furrows. The fixed cheeks are about two-thirds the width of the glabella and moderately convex; palpebral lobes small, and placed about their own length from the frontal rim; frontal rim apparently very narrow, and separated from the glabella and fixed cheeks by a narrow, distinct groove.

Surface finely pustulose under a strong lens.

Formation and Locality.—Middle Cambrian: (C10) Lower shale member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 40 (part of the third list of fossils), and fig. 8*a* (bed 35), p. 29], about 3 miles (4.8 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Collected by Eliot Blackwelder.

A portion of a pygidium is also doubtfully referred to this genus from Locality C30, Middle Cambrian: layer in black oolite of the Ch'ang-hia limestone [Blackwelder, 1907*a*, p. 33 (part of first list of fossils)], 25 feet (7.5 m.) above the second cliff at an elevation of 1,700 feet (568.9 m.) on top of the long north and south ridge at Ch'ang-hia, Shan-tung, China.

Collected by Eliot Blackwelder.

Genus LEVISIA Walcott.

Levisia WALCOTT, 1911, Smithsonian Misc. Coll., vol. 57, No. 4, p. 86. (Described and discussed as a new genus essentially as below.)

This genus is proposed to include a group of small trilobites represented by *Agraulos agenor* Walcott [1905*b*, p. 44]. The cranidium is strongly convex; glabella truncato-conical, tumid, and with only a trace of glabellar furrows; occipital ring narrow at the sides, broadening rapidly toward the center, convex, and extending backward into an obtuse spine. Frontal limb very narrow and passing almost without any line of demarcation into the rather broad, slightly convex frontal margin of the cephalon. Fixed cheeks tumid, about half as wide as the glabella, and with small palpebral lobes midway of their length. Postero-lateral limbs rather short and marked by a deep, narrow, intermarginal posterior furrow that separates a narrow, rounded margin.

Genotype.—*Agraulos agenor* Walcott [1905*b*, p. 44, and 1911, plate 15, fig. 7]. A second species, *Levisia adrastia* (Walcott) [1905*b*, p. 61], has the same generic characters. Its surface has the same pitting and in addition a few relatively large, scattered granules.

Levisia adrastia (Walcott).

Plate 16, Figures 5, 5*a*.

Menocephalus adrastia WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 61. (Species described essentially as below.)

This is a minute cephalon, having a strongly convex, almost globular glabella that rises abruptly from the deep dorsal furrow. A shallow furrow outlines small postero-lateral lobes at the base of the glabella; occipital furrow narrow and distinct; occipital ring slightly convex back of the occipital furrow, narrow at the sides, and widening gradually toward the center.

Fixed cheeks about one-half the width of the glabella, strongly convex; frontal limb obsolete; frontal rim about half as wide as the fixed cheeks, slightly convex, and separated from the fixed cheeks by a transverse, narrow, shallow groove.

Surface with shallow pits under a strong lens, with a few scattered larger granules.

The length of the glabella and frontal rim is 2.5 mm. in one specimen, with an occipital ring about 1 mm. long.

The above is all that is known of this form. Its globose glabella, convex fixed cheeks, and occipital ring distinguish it from other species and at the same time bring it close to *Levisia agenor*. What I considered to be fine granules on the surface when describing the species in 1905, I now recognize as the irregular ridges about the shallow pits.

Formation and Locality.—Middle Cambrian: (C30) Layer in black oolite of the Ch'ang-hia limestone [Blackwelder, 1907*a*, p. 33 (part of first list of fossils)], 25 feet (7.5 m.) above the second cliff at an elevation of 1,700 feet (568.9 m.) on top of the long north and south ridge at Ch'ang-hia, Shan-tung, China.

Collected by Eliot Blackwelder.

Levisia agenor (Walcott).

Plate 14, Figure 19.

Agraulos agenor WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 44. (Species described essentially as below.)

Levisia agenor (Walcott), 1911, Smithsonian Misc. Coll., vol. 57, p. 86, pl. 15, fig. 7. (Referred and figured as genotype of new genus *Levisia*.)

Glabella slightly truncato-conical, strongly convex; occipital furrow rounded, clearly defined; occipital ring slightly convex, subtriangular in outline, narrow at the sides, and broadening out to an obtuse spine behind; dorsal furrow narrow and clearly defined.

Fixed cheeks about one-half the width of the glabella, convex, rising from the dorsal furrow and arching down to a small palpebral lobe; the fixed cheeks slope rapidly backward to a short postero-lateral limb, and anteriorly to a rather broad, very slightly convex frontal limb; a rather deep, narrow furrow occurs within the elevated margin of the postero-lateral limb.

Surface minutely pitted under a strong magnifier; the shallow pits are formed apparently by an irregular network of elevated lines.

The only specimen of the cephalon representing this species is 2.5 mm. long.

Formation and Locality.—Middle Cambrian: (C25) Limestone about 50 feet (15 m.) below the Ku-shan shale in the uppermost beds of the Ch'ang-hia formation [Blackwelder, 1907*a*, p. 33 (part of the last list of fossils)], at Ch'ang-hia, Shan-tung, China.

Collected by Eliot Blackwelder.

Levisia nasuta Walcott.

Levisia nasuta WALCOTT, 1911, Smithsonian Misc. Coll., vol. 57, No. 4, p. 87, plate 17, fig. 5, and text-figs. 7 and 7*a*, p. 87. (Described and discussed as a new species.)

Two Canadian species referred to this genus are found in association, *Levisia nasuta* and *L. richardsoni*. The glabella of *L. nasuta* is very convex; fixed cheeks narrow and merging anteriorly into the bluntly pointed frontal limb and margin. A front and a side view of the specimen are represented on plate 17, Walcott, 1911.

Formation and Locality.—Upper Cambrian conglomerate, at Point Lévis, Quebec.

Levisia richardsoni Walcott.

Levisia richardsoni WALCOTT, 1911, Smithsonian Misc. Coll., vol. 57, No. 4, p. 86, plate 17, figs. 4 and 4*a*. (Described and discussed as a new species essentially as below.)

The species associated with *L. nasuta* occurs with the same Upper Cambrian fauna in the bowlders of the conglomerate at Point Lévis, opposite Quebec, Canada. To this species I have given the name of *Levisia richardsoni* in recognition of the fine collecting work done by Mr. J. Richardson under the direction of Sir William E. Logan.

Genus PTYCHASPIS Hall.

Ptychaspis HALL, 1863, 16th Annual Report New York State Mus. Nat. Hist., p. 170.

Ptychaspis acamus Walcott.

Plate 16, Figures 18, 18*a*.

Ptychaspis acamus WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 69. (Species described as below.)

This species is represented by specimens of the glabella and fragments of the fixed cheeks. The glabella is moderately convex at the back and strongly convex on the frontal lobe; it is divided by a strong, backward-arching furrow, which separates the posterior portion as a transverse lobe, and the anterior as a large lobe about as long as broad; the latter is marked by two narrow, short, slightly impressed furrows on the sides of the lobe; occipital furrow strongly rounded, deep, and arching forward at the center; occipital ring about the middle of the posterior lobe of the glabella nearly flat, and with a small, sharp node at the center near the back margin; frontal rim a rounded, narrow border in front of the deep, narrow dorsal furrow; dorsal furrow narrow and deep opposite the palpebral lobe.

Fixed cheeks rise rapidly from the dorsal furrow; they are narrow and convex; palpebral lobes unknown; the anterior lobe of the glabella slightly overhangs the dorsal furrow, which is deep and rounded.

Surface marked with low, large pustules and very faint punctæ.

The type specimen of the cephalon in the collection has a length of 11 mm., with a width of 6 mm.

This species is characterized by the form of the large frontal lobe, the strong transverse furrows, and narrow posterior lobe of the glabella, and its peculiar surface.

The typical specimens of this species were referred in the original description to the Middle Cambrian, Ch'ang-hia formation. Further study and comparison with material from the upper part of the Upper Cambrian, Ch'au-mi-tién formation, lead me to think that it is highly probable that the specimens labeled as from the Ch'ang-hia formation were collected from the higher horizon of the Ch'au-mi-tién, and accidentally placed with material from the Ch'ang-hia. This is rendered more probable, as the two lots of specimens were collected at and near Ch'au-mi-tién. The specimens from the upper part of the Ch'au-mi-tién formation appear to be identical with the type, and from a lithologically similar limestone. In view of this, and the fact that the genus *Ptychaspis* is unknown from the Ch'ang-hia formation, I have changed the reference to the Upper Cambrian, Ch'au-mi-tién formation.

Formation and Locality.—Upper Cambrian: (C45) Limestone about 40 feet (12 m.) below the top of the Ch'au-mi-tién limestone [Blackwelder, 1907*a*, p. 36 (part of third list of fossils)], at Ch'au-mi-tién, Shan-tung, China.

Collected by Eliot Blackwelder.

Ptychaspis baubo (Walcott).

Plate 17, Figures 2, 2*a*.

Dikelocephalus (?) baubo WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 91. (Species described essentially as below.)

The description of *Ptychaspis brizo* applies to this form, with the exception that *P. baubo* has a more rounded front to the glabella, and its frontal rim and border vary somewhat in form. In *P. baubo* the palpebral lobe is preserved, and shows it to have been relatively small and short, and marked just within the rim by a rather deep furrow. A cephalon of *P. baubo* 16 mm. in length has a glabella 12 mm. in length, frontal rim and limb, 2 mm., and occipital furrow and ring, 2 mm. in length; the glabella has a width of 9 mm. opposite the palpebral lobe.

The surface is marked by strong, scattered pustules over the glabella; little trace of them on the fixed cheeks and frontal rim. The two specimens of the cephalon of this species in the collection vary somewhat in the form of the frontal rim, it being nearly flat in one and slightly concave in the other.

The most nearly related form is *Ptychaspis brizo* [p. 181].

Formation and Locality.—Upper Cambrian: (C64) Upper limestone member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 42 (first list of fossils), and fig. 10 (bed 20), p. 38], 2.7 miles (4.3 km.) southwest of Yen-chuang, and (C61) a dense black limestone in the uppermost limestone member of the Kiu-lung group [idem, pp. 37 and 41 (third list of fossils), and fig. 10 (bed 13), p. 38], 3 miles (4.8 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Collected by Eliot Blackwelder and Li San.

Ptychaspis bella Walcott.

Plate 17, Figure 9.

Ptychaspis bella WALCOTT, 1906, Proc. U. S. Nat. Mus., vol. xxx, p. 585. (Described as a new species essentially as below.)

This species is represented by a single specimen of the central portions of the cephalon, exclusive of the postero-lateral limbs and free cheeks. Glabella subrectangular in outline, moderately convex, and crossed by a backward-arching furrow which separates a narrow segment from the large anterior lobe, which has a length of 6.6 mm. and a width at the center of 5 mm.; the anterior lobe of the glabella is marked close to the dorsal furrow by very short furrows which indicate the second pair of glabellar furrows; the posterior transverse furrow is rather broad and deep at the sides, becoming somewhat shallower at the center; the posterior segment has a uniform width across the central portions, widening out at the ends in front; occipital furrow transversely rounded and rather deep; occipital ring transverse, slightly convex, and about the same width as the posterior segment of the glabella; dorsal furrow deep and strong at the sides and in front of the glabella.

Fixed cheeks narrow and rising abruptly from the dorsal furrow, nearly flat opposite the palpebral lobes; they slope abruptly downward toward the posterior furrow and toward the frontal rim; palpebral lobes narrow, rounded, and separated from the fixed cheeks by strong, narrow furrows; frontal rim convex, prominent, and separated from the glabella by the deep dorsal furrow and from the fixed cheeks by a narrow, deep furrow that extends obliquely outward and forward from opposite each antero-lateral angle of the glabella.

The surface of the glabella is marked by raised, irregular, more or less inosculating, sharp ridges, the general direction of which is transverse to the axis of the glabella; the fixed cheeks are marked by ridges somewhat like those on the glabella, which are subparallel to the dorsal furrow and the furrow within the palpebral lobes; the ridges on the frontal limb are broken up into large granulations by the inosculating furrows. A cephalon 11 mm. in length has a width of 12 mm. at the palpebral lobes.

The general form of the central parts of the cephalon of this species suggests *Ptychaspis acamus* [p. 179]. It differs from the latter in the form of the glabella in front of the transverse glabellar furrow, the elevated lines on the fixed cheeks instead of granulations, and in minor details of the occipital and glabellar furrows.

Formation and Locality.—Upper Cambrian: (C74) A dense blue dolomitic limestone at the top of the Ki-chóu limestones [Willis and Blackwelder, 1907, pp. 139 and 145 (fifth list of fossils)], 4 miles (6.4 km.) east of Fang-lan-chön, Shan-si, China.

Collected by Eliot Blackwelder.

Ptychaspis brizo (Walcott).

Plate 17, Figures 3–5.

Dikelocephalus (?) brizo WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 92. (Species described as below.)

This species is represented by the anterior portions of a large, moderately convex cephalon, exclusive of the free cheeks. The glabella is subquadrilateral, with the sides slightly incurved and the front nearly transverse; it is marked by a strong pair of posterior furrows that penetrate obliquely backward nearly to the median line; a second pair incline slightly backward and penetrate to about one-third the distance across; a third pair, narrow and very slightly impressed, extend in at right angles to the sides a little less than one-third the distance; occipital furrow well defined, with a slight, elongate, pit-like depression at the antero-lateral angles of the glabella.

Fixed cheeks very narrow, not much more than a ridge opposite the palpebral lobes; palpebral lobes unknown; palpebral ridge rounded, and dividing the fixed cheek into the flat posterior portion and the rather rapidly sloping frontal portion that passes down into the concave frontal limb; frontal limb short, concave, and bordered by a rounded, thick frontal rim.

Surface marked by numerous, more or less irregularly placed, strong pustules, except in the dorsal furrow and the concave frontal limb.

The fragmentary specimens representing this species indicate a length for the glabella of 22 mm., with a width in front of 14 mm.; the concave frontal limb has a length of 2.5 mm., and the thickened rounded rim has a length of about 1.5 mm. The fixed cheek at the palpebral lobe has a width of 2 mm.

The form of the glabella, frontal rim, and narrow fixed cheeks suggests *Dikelocephalus*, but the strongly pustulose surface is not characteristic of the typical forms of that genus.

Formation and Locality.—Upper Cambrian: (C38) Crystalline limestone near the base of the Ch'au-mi-tién limestone [Blackwelder, 1907*a*, p. 36 (part of first list of fossils)], at Ch'au-mi-tién, Shan-tung, China.

Collected by Eliot Blackwelder.

Ptychaspis cacus Walcott.

Plate 17, Figures 10, 11.

Ptychaspis cacus WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 69. (Described as a new species essentially as below.)

General form of cephalon, exclusive of the free cheeks, subrhomboidal, rounded in front, strongly convex. Glabella moderately convex over the posterior portion, strongly convex at the frontal lobe; the posterior portion is divided into two lobes, of about equal width, by the broad, rounded, transverse posterior furrow and a narrow, slightly impressed anterior furrow, both of which arch slightly backward toward the center; the frontal lobe is about as long as the two posterior lobes and arches with uniform curve over to the dorsal furrow; it is convex but not globose; it is marked about midway on each side by a short, very slightly impressed, narrow furrow, which penetrates it at right angles to the dorsal furrow; occipital furrow broad, strong, and arching slightly forward at the center; occipital ring about as wide as the posterior lobe of the glabella, moderately convex, and arching slightly forward near the center; dorsal furrow strongly defined at the sides and somewhat less so in front of the glabella; a shallow pit occurs opposite the antero-lateral angle of the glabella.

Fixed cheeks narrow and convex; they slope gently backward and merge into the postero-lateral limb, and forward, in advance of the palpebral lobe, slope downward to the rounded frontal limb; palpebral lobes broken away, but from the form of the fixed cheek they appear to have been about one-third the length of the cephalon; postero-lateral limbs about as long as the width of the glabella, and marked by a broad, strong furrow within the narrow postero-lateral margin; frontal limb and rim united to form a rounded, downward-curving frontal border of the cephalon, separated from the glabella by the strong dorsal furrow.

Surface marked by numerous, irregularly placed pustules, except in the furrows of the glabella, dorsal furrow, and furrow on the postero-lateral limbs.

The type and only specimen of the cephalon in the collection has a length of 17 mm., with the glabella 10 mm. in width and 11 mm. long.

In size and general appearance this species may be compared with *P. ceto* [plate 16, fig. 17]. It differs in its strongly pustulose surface, less convex glabella and fixed cheeks, and in the form of the frontal border of the cephalon. At first sight it is apparently identical with *P. calyce* [plate 16, fig. 15], but it differs in the form of the transverse furrows and the frontal lobe of the glabella, which in *P. calyce* is globose, like that of *P. ceto*.

Formation and Locality.—Upper Cambrian: (C64) Upper limestone member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 42 (first list of fossils), and fig. 10 (bed 20), p. 38], 2.7 miles (4.3 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Collected by Eliot Blackwelder.

Ptychaspis cadmus Walcott.

Plate 16, Figures 19, 19*a*.

Ptychaspis cadmus WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 70. (Described as a new species essentially as below.)

This species is represented by more or less fragmentary specimens of the central portions of the cephalon, exclusive of the free cheeks. Glabella moderately convex at the back and strongly convex at the front, marked by a posterior transverse furrow that arches slightly backward, cutting off a narrow lobe between it and the dorsal furrow; anterior lobe a little longer than wide, and marked by a pair of short, narrow furrows opposite the anterior end of the palpebral lobe; the anterior lobe is convex, but not globose; occipital furrow strong; occipital ring unknown; dorsal furrow strong and rather deep.

Fixed cheeks very narrow and disappearing into the dorsal furrow in front of the palpebral lobe; posteriorly they slope downward as an irregular ridge to the postero-lateral limb; palpebral lobes about one-fourth the length of the cephalon and marked by a deep groove within the narrow rim; frontal limb narrow and sloping outward and downward to the frontal margin from the broad, strong dorsal furrow; it is marked by two transverse rows of large tubercles; postero-lateral limbs unknown.

The surface of the cephalon, except the furrows, is thickly covered with large pustules.

A glabella 11 mm. in length has a width of 8 mm.; none of the specimens is sufficiently perfect to give measurements for the entire length of the cephalone.

The species is characterized by the very narrow fixed cheeks and strongly pustulose surface. It is associated with *P. calchas* [plate 16, fig. 13].

Formation and Locality.—Upper Cambrian: (C41) Lower part of the Ch'au-mi-tién limestone [Blackwelder, 1907*a*, p. 36 (part of the first list of fossils)], 2.7 miles (4.3 km.) southwest of Ch'au-mi-tién, Shan-tung, China.

Collected by Eliot Blackwelder.

Ptychaspis calchas Walcott.

Plate 16, Figures 13, 13*a*.

Ptychaspis calchas WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 71. (Described as a new species essentially as below.)

Of this species only more or less imperfect specimens of the central portions of the cephalon, exclusive of the free cheeks, are known. Glabella slightly convex on the posterior half and moderately convex at the frontal lobe; it is divided by two transverse, rather strong, shallow furrows into two narrow lobes that arch slightly backward, and an anterior lobe that measures a little more than half the length of the glabella; a pair of very slightly impressed and short furrows marks the side of the frontal lobe a little back of the center; occipital furrow broad, shallow, and about the same strength as the two furrows crossing the glabella; occipital ring narrow at the sides, increasing in width toward the center, where it rises at the back above the general level of the glabella; dorsal furrow broad and rounded.

Fixed cheeks scarcely more than a very narrow ridge rising from the broad dorsal furrow to the palpebral lobe and sloping gently backward into the postero-lateral limb and forward, in front of the palpebral lobe, into the frontal border of the cephalon; palpebral lobe about one-fourth the length of the cephalon and marked by a strong furrow within the narrow rim; frontal rim nearly flat, of medium width, and sloping forward and downward from the dorsal furrow to the frontal margin; postero-lateral limb about as long as the width of the glabella, and marked by a broad, shallow furrow within the narrow posterior margin.

The cast of the interior surface of the test appears to be minutely punctate under a strong lens, and fragments of the exterior appear to be smooth.

The largest specimen of the cephalon in the collection has a length of about 22 mm.; a specimen 1 mm. in length has a glabella 5 mm. in width, with a fixed cheek a little less than 2 mm. in width from the sides of the glabella across the dorsal furrow to the furrow on the palpebral lobe.

This species differs from the described species of the genus in the low convexity of the glabella, the uniformity of the occipital and two posterior furrows of the glabella, and the apparently smooth surface.

Formation and Locality.—Upper Cambrian: (C41) Lower part of the Ch'au-mi-tién limestone [Blackwelder, 1907*a*, p. 36 (part of the first list of fossils)], 2.7 miles (4.3 km.) southwest of Ch'au-mi-tién, Shan-tung, China.

Collected by Eliot Blackwelder.

Ptychaspis callisto Walcott.

Plate 16, Figures 14, 14*a*.

Ptychaspis callisto WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 72. (Described as a new species essentially as below.)

Of this species only the central portions of the cephalon exclusive of the free cheeks, are known. Glabella moderately convex, and divided into a narrow posterior lobe by a broad, rounded, deep transverse furrow that curves slightly backward, and an anterior lobe, about as long as wide, marked upon its lateral slopes by two pairs of short, narrow furrows; it is broadly rounded, almost transverse in front, and its sides are subparallel; occipital furrow broad and deep, and arching slightly forward at the center; occipital ring narrow at the ends, widening and rising gradually toward the center, which appears to have been elevated above the general surface of the cephalon; dorsal furrows strong and deep.

Fixed cheeks narrow, rising abruptly from the dorsal furrow and extending laterally to the furrow within the rim of the palpebral lobe; they slope gently backward to the postero-lateral limb, and more abruptly forward to a strong furrow that separates the frontal, rounded margin of the cephalon from the glabella; frontal limb and rim combined in a rounded frontal border, which corresponds in its section to about the same curvature as the section of the furrow between the border and the glabella; postero-lateral limbs about as long as the width of the glabella, and marked by a broad, rather deep groove within the narrow posterior margin.

Surface of the cast of the interior of the test with numerous rather large, scattered punctæ, and very fine punctæ seen only with the aid of a strong lens; a fragment of the outer surface shows it to have been strongly punctate, with fine punctæ corresponding to the punctæ seen on the interior.

The largest cephalon in the collection has a length of 13 mm.

This species is strongly characterized by the broad, strong posterior furrow and narrow posterior lobe of the glabella, and the subquadrate, moderately convex frontal lobe; also the elevated occipital ring and punctate surface.

Formation and Locality.—Upper Cambrian: (C64) Upper limestone member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 42 (first list of fossils), and fig. 10 (bed 20), p. 38], 2.7 miles (4.3 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Collected by Eliot Blackwelder.

Ptychaspis calyce Walcott.

Plate 16, Figures 15, 15*a*.

Ptychaspis calyce Walcott, 1905, Proc. U. S. Nat. Mus., vol. xxix, p. 72. (Characterized as a new species as below.)

In general form, convexity, and size the corresponding parts of this species follow those of *P. ceto* [plate 16, fig. 17]. It differs from the latter in having a strongly pustulose surface instead of irregular, more or less concentric ridges and furrows. The largest specimen of the cephalon in the collection has a length of 17 mm.

Formation and Locality.—Upper Cambrian: (C42) In the central part of the Ch'au-mi-tién limestone [Blackwelder, 1907*a*, p. 36 (second list of fossils)], 1.8 miles (2.9 km.) west-southwest from the temple on Tsing-lung-shan, 7.5 miles (12 km.) east of Ch'au-mi-tién, Shan-tung; also (C64), upper limestone member of the Kiu-lung group [idem, pp. 37 and 42 (first list of fossils), and fig. 10 (bed 20), p. 38], 2.7 miles (4.3 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Collected by Bailey Willis and Eliot Blackwelder.

Ptychaspis campe Walcott.

Plate 16, Figure 16.

Ptychaspis campe Walcott, 1905, Proc. U. S. Nat. Mus., vol. xxix, p. 73. (Described as a new species essentially as below.)

This species is represented by a fragment of a small cephalon that is so distinct in its surface granulation, large eye-lobe, and frontal portion of the cephalon that it can not be readily confused with any other species. The glabella is divided by two narrow, transverse, slightly backward curving furrows into two narrow lobes and a large anterior lobe that is marked by two pairs of short, very narrow furrows on the lateral slopes; the anterior lobe is about as long as wide, slightly convex behind and

strongly convex in front, but not at all globose or tumid; it is broadly rounded, almost transverse in front, and has parallel sides; frontal limb very narrow in front of the glabella, widening at the sides; it is separated from a downward-sloping frontal rim by a very narrow transverse furrow; the frontal rim is very slightly convex, and from two to three times as wide as the frontal limb in front of the glabella; dorsal furrow narrow and deep on the sides, and little more than a line in front of the glabella.

Fixed cheeks very narrow at the front and back and merging into a large palpebral lobe at the center; they rise rapidly from the dorsal furrow and arch over into the furrow within the narrow palpebral lobe; palpebral lobe extends from opposite the anterior pair of furrows on the frontal lobe of the glabella back to the posterior transverse furrow.

Surface marked by large, low, closely arranged granulation or pustules.

This is a small species, the type specimen of the glabella having a length of only 4 mm., with a width of 2 mm.

Formation and Locality—Upper Cambrian: (C42) In the central part of the Ch'au-mi-tién limestone [Blackwelder, 1907*a*, p. 36 (second list of fossils)], 1.8 miles (2.9 km.) west-southwest from the temple on Tsing-lung-shan, 7.5 miles (12 km.) east of Ch'au-mi-tién, Shan-tung, China.

Collected by Bailey Willis.

Ptychaspis ceto Walcott.

Plate 16, Figures 17, 17*a–d*.

Ptychaspis ceto WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 73. (Described and discussed as a new species essentially as below.)

Cephalon, exclusive of the free cheeks, subrhomboidal in outline, strongly convex. Glabella large, strong, with very convex frontal lobe, sides subparallel, front broadly rounded; two strong glabellar furrows cross transversely from side to side, dividing the glabella into two rather narrow posterior lobes and an anterior globose lobe that slightly overhangs the frontal rim; occipital furrow about as strong as the two glabellar furrows; occipital ring narrow and slightly rounded, and elevated at the center; dorsal furrows strong and deep on the sides and in front of the glabella.

Fixed cheeks with the dorsal furrow about two-thirds the width of the glabella, the fixed cheeks forming an elevated ridge at the palpebral lobe, with an elevated, short ridge opposite the anterior end of the palpebral lobe, that is crossed by three transverse ridges, as seen in the cast of the inner surface; in front of the elevated portion the cheek drops gently to the frontal rim; back of the palpebral lobe the cheek slopes gently and merges into the postero-lateral limb; palpebral lobe narrow, elongate, a little more than one-half the length of the cephalon, and separated from the fixed cheek by a narrow, deep furrow; postero-lateral limb about as long as the width of the glabella at the base, and marked by a broad, deep, rounded groove, within the sharp, elevated posterior margin; frontal limb very short and sloping downward into the rounded frontal rim; the frontal limb and rim form scarcely more than the outer border of the strong dorsal furrow.

Outer surface unknown, as in all the specimens the test clings to the matrix; this latter fact indicates that it was roughened, probably tuberculose. The cast of the frontal lobe of the glabella shows a number of irregular, concentric ridges and grooves subparallel to the frontal margin.

The largest cephalon in the collection has a length of 14 mm., with a width at

the palpebral lobes of 17 mm.; the glabella is 8 mm. in width, with a length, including the occipital ring, of 14 mm.

This species differs from *Ptychaspis cacus* [plate 17, figs. 10, 11] in the globose, overhanging frontal lobe of the glabella, and the form of the frontal rim, features that also separate it from *P. cadmus* [plate 16, fig. 19] and *P. calchas* [plate 16, fig. 13]. From *P. acamus* [plate 16, fig. 18] it differs in the form of the frontal lobe of the glabella and the transverse lobe back of it. The globose glabella resembles that of *P. granulosa* Owen [1852, p. 575], except that it is more globose and overhangs the frontal border. *Ptychaspis granulosa* has a different form from the other Chinese species.

Formation and Locality.—Upper Cambrian: (C38) Crystalline limestone near the base of the Ch'au-mi-tién limestone [Blackwelder, 1907*a*, p. 36 (part of first list of fossils)], at Ch'au-mi-tién, and (C34), purplish-gray limestone about 100 feet (30 m.) above the base of the Ch'au-mi-tién formation [idem], in road at northeastern corner of small village near Ch'au-mi-tién; also (C54), lower part of Ch'au-mi-tién limestone [idem, p. 42 (part of last list of fossils)], near top of limestone knoll two-thirds of a mile (1.1 km.) west of Tsi-nan; (C56), lower part of Ch'au-mi-tién limestone, 25 feet (7.5 m.) below the top of Pagoda Hill [idem], 1 mile (1.6 km.) west of Tsi-nan; and (C64), upper limestone member of the Kiu-lung group [idem, pp. 37 and 42 (first list of fossils), and fig. 10 (bed 20), p. 38], 2.7 miles (4.3 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Collected by Eliot Blackwelder.

Ptychaspis ? spp. undt. Walcott.

Plate 17, Figures 1, 6–8; Plate 21, Figures 14, 15.

Ptychaspis sp. undt. Walcott, 1905, Proc. U. S. Nat. Mus., vol. xxix, p. 74. (Species referred to as in first paragraph below.)

There are several species of *Ptychaspis* that occur in the Upper Cambrian zone that are too imperfect for description. One of these has the general form of *P. campe*, but it differs in the exceedingly narrow fixed cheeks and flat frontal border, while having the same type of pustulose surface. It occurs at Locality C47, Upper Cambrian, upper part of the Ch'au-mi-tién limestone [Blackelder, 1907*a*, fig. 9 (top of bed 1), p. 35], at the top of a high col at Ch'au-mi-tién, Shan-tung, China.

Free cheeks referred more or less doubtfully to the genus occur as follows:

Plate 17, figure 1; plate 21, figure 14, at Locality C64, Upper Cambrian, upper limestone member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 42 (first list of fossils), and fig. 10 (bed 20), p. 38], 2.7 miles (4.3 km.) southwest of Yen-chuang, Shan-tung.

Plate 17, figure 6; plate 21, figure 15, at Locality C54, Upper Cambrian, lower part of Ch'au-mi-tién limestone [Blackwelder, 1907*a*, p. 42 (part of last list of fossils)], near top of limestone knoll two-thirds of a mile (1.1 km.) west of Tsi-nan, Shan-tung.

Plate 17, figure 7, at Locality C67, Upper Cambrian, stream gravels (these are taken from the wash from the mountains south of the city), used in making the railroad grade, one-third mile (0.5 km.) west of the west city gate at Tsi-nan, Shan-tung.

Plate 17, figure 8, at Locality C33, Upper Cambrian, about 100 feet (30 m.) above the base of the Ch'au-mi-tién limestone, 9 miles (14.4 km.) north of Sin-t'ai-hién, Shan-tung, China.

Also from Locality C50, Upper Cambrian, upper part of the Ch'au-mi-tién limestone [Blackwelder, 1907*a*, p. 36 (part of third list of fossils)], on a low spur at Ch'au-mi-tién, Shan-tung, China.

Collected by Eliot Blackwelder.

Genus ANOMOCARE Angelin.

Anomocare ANGELIN, 1854 (edition 1878), Pal. Scandinavica, pt. 1, p. 24. (Described as a new genus.)
Anomocare (Angelin) WALCOTT, 1911, Smithsonian Misc. Coll., vol. 57, No. 4, p. 87. (Discussed essentially as below.)

For the purpose of comparison a cranidium, free cheek, and pygidium of *Anomocare læve* are illustrated by figures 1, 1*a–b*, plate 18; also an entire dorsal shield of *Anomocare convexa* Walcott [figs. 3, 3*a–c*, plate 18] from the Middle Cambrian strata of Alabama.

Genotype.—Anomocare læve Angelin [1854, edition of 1878, p. 25].

Anomocare alcinoe Walcott.

Plate 18, Figures 6, 6*a–b*.

Anomocare alcinoe WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 47. (Described as a new species essentially as below.)

This species is represented by a single specimen, preserving the anterior portions of the central part of the cephalon, exclusive of the free cheeks. These parts indicate that the cephalon was large, moderately convex, and longitudinally quadrilateral, exclusive of the free cheeks. Glabella slightly convex, rising gently from the dorsal furrow toward the center; faint indications of three pairs of glabellar furrows are shown by reflected light over the smooth surface; sides subparallel to the rather broadly rounded front; occipital furrow and ring unknown.

Fixed cheeks about one-half the width of the glabella, nearly flat opposite the palpebral lobes, and sloping gently to the frontal limb, into which they merge in front of the palpebral lobes; the palpebral ridge, starting just back of the antero-lateral angle of the glabella, extends obliquely out to the narrow palpebral lobe; frontal limb nearly flat; it slopes gently from the glabella and palpebral lobes to a raised line which separates it from the broad, slightly concave frontal rim.

The surface appears to be smooth under a strong lens.

An associated pygidium has a broad, planulate margin and convex axis, with slight indications of about six segments.

The most nearly related form from China is *Coosia decelus* [plate 21, figs. 8, 8′]. In the latter form the frontal rim is slightly convex, while in *A. alcinoe* it is slightly concave.

Formation and Locality.—Middle Cambrian: (C57) In limestone nodules in the lower shale member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 40 (first list of fossils)], 3 miles (4.8 km.) south of Kao-kia-p'u, and 4 miles (6.4 km.) north of Sin-t'ai-hién, Sin-t'ai district, Shan-tung, China.

Anomocare convexa Walcott.

Plate 18, Figures 3, 3*a–c*.

Anomocare convexa WALCOTT, 1911, Smithsonian Misc. Coll., vol. 57, No. 4, pp. 87–90, plate 17, figs. 2, 2*a–d*. (Described and discussed as a new species essentially as below.)

Dorsal shield large, elliptical in outline; axial lobe narrow and convex; cephalon semicircular in outline with the genal angles produced into spines. The facial sutures cut the posterior margin a short distance within the genal angles and extend inward with a slight curvature and forward to the base of the palpebral lobe; arching around the palpebral lobe, they extend downward and slightly forward a short distance and then with a broad sweep curve inward, cutting the anterior margin on a line with the outer edge of the palpebral lobe. Cranidium with a large glabella, concave frontal limb, relatively narrow fixed cheeks, and elongate, narrow postero-lateral limbs. Glabella moderately convex, with the sides gradually con-

verging to its broadly rounded front margin; it is marked by four pairs of short furrows that penetrate obliquely inward and backward from the sides; the two posterior lobes outlined by the oblique furrows are roughly subtriangular in outline, the furrows penetrating over nearly one-third of the distance toward the center. The second pair appears to be represented by rather prominent, slightly convex tubercles, and extends about one-fourth the distance across the glabella. Viewed with a transverse light, the second pair of lobes appears to be a forward extension of the posterior pair of lobes, since the furrows back of them are not quite so deep as the more oblique furrow just inside of the inner postero-lateral margin of the second pair of furrows; the third pair of lobes extend obliquely inward and backward about one-third of the distance across the glabella; the fourth pair is outlined posteriorly by a rather deep furrow that increases in width from the outer margin inward for a short distance so as to form a shallow, triangular area. The anterior margin of the fourth pair of glabellar lobes is just back of a pit which occurs on the side of the glabella opposite the inner end of the palpebral ridge. On very finely preserved specimens a narrow, gently arched ridge appears to represent the extension of the palpebral ridges on the fixed cheeks. There is also a transverse furrow just within the anterior margin of the glabella. The glabellar furrows and lobes described indicate that the glabella is formed by the union of five or possibly six of the original segments of one of the ancestral forms of this trilobite [see Walcott, 1910*a*, pp. 237–238]. The occipital ring is separated from the glabella by a furrow that is rather broad and deep on each side, and narrow, shallow, and arching slightly forward across the center; occipital ring slightly convex, broad across the central portions, narrowing and terminating directly in the line of the posterior intermarginal furrow of the fixed cheeks. Fixed cheeks about half as wide as the glabella, nearly flat within the palpebral lobe and ridge, and sloping gently down into the postero-lateral limb. They are interrupted in front by the strong palpebral ridges which extend backward from a point opposite the anterior pair of glabellar furrows and merge into the arched palpebral lobes; in front of the palpebral ridge the cheeks descend rapidly and merge into the frontal limb; the postero-lateral limb is long and almost entirely made up of the rounded, narrow posterior rim, strong intermarginal furrow, and a narrow area between the furrow and the facial suture. Palpebral lobe of medium length; in a cephalon 18 mm. in length it has a length of 4 mm.; it is narrow and raised a little above the surface of the fixed cheeks. Frontal limb broad and strongly concave in large cephala, becoming less so in smaller; in front of the glabella it slopes rather rapidly downward and then upward with a gentle curve to the thin, rounded edge. Free cheeks gently convex but becoming slightly concave toward the outer margin in the larger specimens. The genal angles are extended into short spines.

Thorax with eleven nearly transverse segments; axial lobe convex and a little more than one-half the width of the pleural lobes. It is strongly defined by a sharp angle where the segments pass into the pleural lobes. Each segment arches forward slightly at the center, also at the sides just before joining the pleural portion of the segment; the pleural lobe of each segment is transverse for about one-half its length, and then it curves gently down toward the falcate termination. The pleural grooves start just within the front rim of each segment next to the axial lobe, and, widening, continue with a nearly uniform width for about two-thirds of the distance outward and then narrow, disappearing some little distance within the termination of the segment.

Pygidium large, moderately convex, with a narrow, strongly convex axial lobe and broad, slightly flattened margin; axial lobe five-sixths of the length of the

pygidium, convex and narrowing gradually from the anterior margin to its termination; it is crossed by from five to six shallow, transverse furrows that outline from six to seven slightly convex rings and a terminal section; from the axial lobe the surface of the pleural lobes slopes at first gently and then quite rapidly down for about two-thirds of their width and then very gradually out to the margin. They are marked by five or six broad furrows and rather broad, flattened ridges that are the continuation on the pleural lobe of the transverse rings on the axial lobe; the posterior margin curves more or less inward toward the median line so as to give a slightly indented outline to the otherwise rounded curve of the sides and posterior margin of the pygidium.

Surface under a strong lens shows numerous pits or pores; the free cheeks and the cranidium in front of the glabella and palpebral ridges are beautifully marked by irregular radiating ridges that branch quite irregularly and are united by irregular cross-ridges so as to give an anastomosing effect.

The dimensions are shown by the figures on plate 18, figures 3 and 3*a*.

The cranidium of this species is much like that of *Anomocare lævе* [plate 18, fig. 1]. Each has a broad, more or less concave frontal limb and margin marked by radiating ridges, large eyes, and elongate glabella marked by five short lobes on each side.

The pygidium in each species is of the same type and the surface has the same punctate character in each.

Anomocare convexa is associated with several other species of *Anomocare*.

Formation and Locality.—Middle Cambrian: (90x) Conasauga formation, in and attached to the outer surface of siliceous nodules in the Conasauga (Coosa) shales, Coosa Valley, east of Center, Cherokee County, Alabama.

Collected by A. M. Gibson, 1884, and Cooper Curtice, 1885.

Anomocare daulis Walcott.

Plate 18, Figures 7, 7*a*.

Anomocare ? daulis Walcott, 1905, Proc. U. S. Nat. Mus., vol. xxix, p. 50. (Described as a new species essentially as below.)

Of this species the central portions of the cephalon, exclusive of the free cheeks, and associated pygidium are known. Glabella rather strongly convex and faintly marked by three pairs of furrows; it narrows slightly toward the rounded front; occipital furrow narrow and curving slightly forward at the center; occipital ring of medium and nearly uniform width from side to side; dorsal furrow shallow and rounded; posteriorly the latter separates a narrow, elongated lobe from the side of the glabella, and joins the occipital furrow; the narrow lobe mentioned extends backward to the occipital furrow and laterally merges into the fixed cheek; from another point of view the dorsal furrow might be considered to pass outside of the narrow, elongate lobe, near the base of the glabella, and the furrow between the glabella and the elongate lobe would then be an inner division of the dorsal furrow. The surface of the glabella is somewhat irregular on account of the lateral furrows, and on account of a rather rounded, broad, longitudinal ridge which extends its entire length.

Fixed cheeks less than half the width of the glabella; they rise from the dorsal furrow and merge into the large eye-lobe, and anteriorly are divided by the strong palpebral ridge which passes into the strong palpebral lobe; in front of the palpebral ridge the cheeks slope downward to a second ridge which extends from the front line of the glabella subparallel to the palpebral ridge as far as the facial sutures; frontal limb relatively long, slightly concave to the narrow, very slightly rounded rim; postero-lateral limbs short and marked by a strong curve within the narrow posterior rim.

Surface smooth under a strong lens.

The associated pygidium has a strong central axis marked by five or six rings that are very distinct on the broad, planulate margins.

This species is strongly characterized by its peculiar glabella, with the elongate, narrow lobes near its base; also by the broad, slightly convex frontal rim.

Formation and Locality.—Middle Cambrian: (C19) Uppermost layers of the Ch'ang-hia limestone [Blackwelder, 1907*a*, p. 33 (part of last list of fossils)], at Ch'ang-hia, and (C26) near the top of the black oolite group in the uppermost layers of the Ch'ang-hia limestone [idem], 2 miles (3.2 km.) north-northeast of Ch'ang-hia, Shan-tung, China.

The first collected by Li San; the second by Eliot Blackwelder.

Anomocare ephori Walcott.

Plate 18, Figures 5, 5*a*–*b*.

Anomocare ephori WALCOTT, 1911, Smithsonian Misc. Coll., vol. 57, No. 4, p. 90, plate 15, figs. 8–8*a*. (Described and discussed as a new species essentially as below.)

This species is represented by specimens of the cranidium and associated pygidia that are referred to it. It is closely related to *Anomocare flava* Walcott [plate 18, fig. 8]. It differs in details of frontal limb and border, glabella, and fixed cheeks. It has a less deeply impressed line between the frontal limb and border than that of *A. flava*.

Formation and Locality.—Middle Cambrian: (35r) Fu-chóu series, limestones near the base of the series just above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general section giving stratigraphic relations], collected in a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria, China.

Collected by J. P. Iddings and Li San.

Anomocare flava Walcott.

Plate 18, Figures 8, 8*a*–*c*.

Anomocare flava WALCOTT, 1906, Proc. U. S. Nat. Mus., vol. XXX, p. 583. (Described as a new species essentially as below.)

Cephalon, exclusive of the free cheeks, quadrilateral and moderately convex. Glabella slightly convex in front, becoming more convex toward the center, along which there is a very slightly indicated longitudinal ridge. A glabella 6 mm. in length has a width of 5.5 mm. at the base and 4 mm. opposite the anterior edges of the palpebral ridges, where the rounded front begins; the posterior pair of glabellar furrows is indicated on one specimen by a slight depression, on another two pairs of furrows are indicated by slight scars about halfway between the center and the sides of the glabella; occipital furrow shallow, scarcely more than indicating the line of division between the glabella and the occipital ring; the latter rises gently toward the center; dorsal furrow clearly indicated at the junction of the glabella and fixed cheeks, and also in front of the glabella.

Fixed cheeks about one-third the width of the glabella, nearly flat back of the palpebral ridges, and sloping gently downward to merge into the frontal limb, and backward to the posterior margin of the cephalon; palpebral ridges low and rather broad; they terminate at the antero-lateral angles of the glabella from whence they extend obliquely backward to merge into the palpebral lobes; palpebral lobes little more than one-fourth the length of the cephalon, and rather prominent; frontal limb in front of the glabella about the same width as the frontal rim; it is slightly convex to the base of the rather abrupt posterior margin of the frontal rim.

The surface is marked by a few minute, scattered pores to be seen only with a strong lens. The largest cephalon has a length of 12 mm., with the same width at the palpebral lobes.

The associated pygidium has a broad, planulate margin, a narrow, convex axis with six rings, indicated by shallow furrows, and a terminal segment; the furrows in the axis are extended out on the pleural lobes, disappearing on the planulate margin.

The central portions of the cephalon of this species differ from *Anomocarella temenus* [plate 20, fig. 7], the nearest related form, in having a shorter glabella in proportion to its width, a tubercle or spine of unknown size on the occipital ring, and a smoother surface on the glabella. The associated pygidium is much like that associated with *A. temenus*, but differs in having a narrower axis marked by more rings.

Formation and Locality.—Middle Cambrian: (C72) Thin green-gray limestone interbedded with ocherous and green clay shales, overlying the massive oolite in the Ki-chóu formation [Willis and Blackwelder, 1907, pp. 139 and 145 (third list of fossils)], 4 miles (6.4 km.), east of Fang-lan-chön, Shan-si, China.

Collected by Eliot Blackwelder.

Anomocare latelimbatum Dames.

Plate 18, Figures 2, 2*a–e*.

Anomocare latelimbatum DAMES, 1883, China, Richthofen, vol. IV, p. 14, plate 2, figs. 9, 10, 13. (Species described, discussed, and illustrated.)

This species is represented in our collections from Shan-tung by two specimens of the cranidium, one of which is well preserved and is illustrated by figures 2*b* and 2*d*. It is identified by comparison with photographs of the type specimens described by Doctor Dames. The second specimen preserves the glabella, fixed cheeks, and palpebral lobes and a portion of the frontal limb.

Doctor Dames states that the type specimens are associated with *Agnostus chinensis* Dames, *Concephalites frequens* Dames, and *Lingulella* 2 spp. in a dense greenish-gray limestone at Sai-ma-ki, Province of Liau-tung, southeast of Mukden, Manchuria, China.

Portions of the dorsal shield are abundant in the dark gray limestones in Liau-tung, Manchuria. Several of these are illustrated.

Formation and Locality.—Middle Cambrian: (C52) In the lower part of the lower limestone member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 39 (second list of fossils), and fig. 7 (bed 22), p. 27], near base of cliffs in mountain 1,000 feet (305 m.) high, 3 miles (4.8 km.) northeast of Sin-t'ai-hién, Shan-tung; also (C2), lower shale member of the Kiu-lung group [idem, pp. 37 and 40 (part of the third list of fossils), and fig. 10 (beds 4 and 5), p. 38], 2 miles (3.2 km.) south of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Collected by Eliot Blackwelder.

Anomocare lisani Walcott.

Plate 18, Figures 4, 4*a–e*.

Anomocare lisani WALCOTT, 1911, Smithsonian Misc. Coll., vol. 57, No. 4, pp. 90–91, plate 15, figs. 9, 9*a–b*. (Described and discussed as a new species essentially as below.)

This fine species is represented by numerous specimens of fragments of the cephalon, segments of the thorax, and entire pygidia. They are all compressed in a fine argillaceous shale and usually only a faint impression remains. The cranidium is not unlike that of *Coosia (?) limbata* (Angelin) [plate 21, fig. 12]; it differs in having a slightly convex or rounded frontal limb and proportionately narrower glabella.

The pygidium is quite different in outline; the rounded indented posterior margin of *C. (?) limbata* [plate 21, fig. 12*a*] is represented by a deep notch that gives a bilobed appearance to the very broad margin; the axial lobe is also longer and broader than that of *C. (?) limbata*. The doublure of the pygidium extends close up to the termination of the furrows of the pleural lobe. The pleural lobes of the thoracic segments have a narrow, strong furrow that extends from the inner, anterior margin diagonally across nearly to the posterior margin of the backward curving, slightly falcate ends of the segment.

The stratigraphic position of this species is about 250 feet (79 m.) above the zone of *Anomocare latelimbatum* Dames.

The specific name is given in recognition of the excellent work done by Li San, who assisted Professors Willis and Iddings in their collecting.

Formation and Locality.—Middle Cambrian: (35q) Fu-chóu series, about 200 feet (61 m.) above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general stratigraphic relations]; collected in a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria, China.

Collected by J. P. Iddings and Li San.

Anomocare megalurus (Dames).

Plate 18, Figures 9, 9*a–f*.

Liostracus megalurus DAMES, 1883, China, Richthofen, vol. IV, p. 20, plate 1, figs. 7, 8, 10. (Species described, discussed, and illustrated.)

Ptychoparia (Liostracus) megalurus (Dames), WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 9. (Listed under subgenus of *Ptychoparia*.)

Numerous fragments of this species occur in a dark shaly limestone in association with *Acrotreta shantungensis* Walcott and *Obolus chinensis* (Walcott). A comparison of photographs of the type specimens described by Dames with the originals of the figures on plate 18 leads me to place them under the same species. Doctor Dames found fragments of *Dorypyge richthofeni* Dames associated with this species at Wu-lo-pu. Prof. J. P. Iddings found fragments of the cephalon in the same association on the island of Tschang-hsing-tau, Liau-tung.

Formation and Locality.—Upper Cambrian: (C37) Upper part of the Ki-chóu limestone [the fossils from this locality are not listed, but the presence of Cambrian strata at the locality is mentioned by Willis and Blackwelder, 1907, p. 146], in dense black limestone nodules in green-gray shales 10 feet (3 m.) below the base of the cliff limestone, 8 miles (12.8 km.) south of Ting-hiang-hién, Shan-si, China.

Collected by Eliot Blackwelder.

Also from Locality 35n, Middle Cambrian, Fu-chóu series, limestone near the base of the series just above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general section giving stratigraphic relations]; collected in a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria, China.

Collected by J. P. Iddings and Li San.

The type specimens described by Doctor Dames were found in a light gray limestone at the foot of a limestone cliff at Wu-lo-pu, Province of Liau-tung, southeast of Mukden, Manchuria, China.

Anomocare minus Dames.

Plate 19, Figures 1, 1*a–d*.

Anomocare minus DAMES, 1883, China, Richthofen, vol. IV, p. 15, pl. 1, fig. 24. (Species described, discussed, and illustrated.)

A comparison of our specimens with a photograph of one of the type specimens described by Dames indicates that as far as the cranidium can serve for identification, the specimens from Yen-chuang are specifically similar to those from Ta-ling.

In the argillaceous shales interbedded in the limestones carrying the *Dorypyge richthofeni* fauna which includes *A. minus* Dames, there are two specimens referred to this species in which parts of the thorax are preserved [figs. 1*c*–*d*]. One of these has thirteen segments in the thorax and both show a pleural lobe wider than the axial lobe. The pleural portion of the segment has a narrow pleural furrow extending from near the front inner margin of the segment diagonally across nearly to the outer posterior margin where the slightly falcate termination of the segment curves slightly backward.

The associated species recorded by Dames is *Liostracus talingensis* Dames. In our collections in Shan-tung we find, with *A. minus* Dames, *Micromitra* (*Paterina*) *labradorica orientalis* (Walcott), *Incuyia abaris* (Walcott), and *Coosia decelus* (Walcott). In Manchuria, Prof. J. P. Iddings found *A. minus* in association with the *Dorypyge richthofeni* fauna.

Formation and Locality.—Middle Cambrian: (C9) Lower limestone member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 39 (third list of fossils), and fig. 8*a* (bed 33), p. 29], 3 miles (4.8 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Also from Localities (36h), Fu-chóu series, shales about 130 feet (40 m.) above the white quartzite, (36e) shales interbedded with limestones, and (35n) limestones near the base of the series just above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general section showing stratigraphic relations] collected in a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria, China.

Collected by J. P. Iddings and Li San.

The type specimens described by Doctor Dames occur in a greenish-brown, dense limestone found in a wall at Ta-ling, Province of Liau-tung, southeast of Mukden, Manchuria, China.

Anomocare ? nereis (Walcott).

Plate 18, Figure 10.

Ptychoparia nereis Walcott, 1906, Proc. U. S. Nat. Mus., vol. xxx, p. 588. (Described as a new species essentially as below.)

This form is represented by several cephala, exclusive of the free cheeks. Glabella and fixed cheeks are moderately convex; glabella prominent, truncato-conical, converging very gently from the base to the slightly rounded front; surface marked by three pairs of short, very slightly impressed furrows, and a very obscure, longitudinal median ridge; occipital furrow shallow but clearly defined; occipital ring nearly flat, sloping from the shallow furrow slightly upward to the posterior margin it narrows at the sides to two-thirds of its width at the center; dorsal furrow narrow, shallow, and clearly defined at the sides of the glabella; in front it is little more than the angle formed by the union of the glabella and frontal limb.

Fixed cheeks narrow, about one-third the width of the glabella, slightly convex opposite the palpebral lobes, and merging into the frontal limb in front of the palpebral ridges, and sloping more gently backward to the posterior furrow; palpebral lobes narrow, about one-third the length of the cephalon, and separated from the fixed cheeks by shallow furrows; postero-lateral limb short, and marked by a rather broad, shallow posterior furrow within a very narrow posterior margin; frontal limb short, sloping down to the very narrow, slightly defined furrow that separates it from the nearly flat, narrow frontal rim.

Surface slightly roughened, but from its condition it is impossible to state whether it is like the surface of *Ptychoparia lilia* [plate 12, fig. 12]. The largest cephalon in the collection has a length of 3.5 mm.

The subrectangular glabella is somewhat like that of *Ptychoparia aclis* [plate 12, fig. 8], but the short frontal limb and flat rim distinguish it from the latter species.

It is associated with *Conokephalina vesta* [plate 13, fig. 9], from which it differs in the form of the glabella and palpebral lobes.

A form closely related to this occurs about 100 feet (30 m.) lower at the same locality and section.

Formation and Locality.—Middle Cambrian: (C69) Limestone in shales about 65 feet (19.5 m.) above the base of the Ki-chóu limestone, and (C72) thin green-gray limestone interbedded with ocherous and green clay shales, overlying the massive oolite in the Ki-chóu formation [Willis and Blackwelder, 1907, pp. 139 and 145 (first and third lists of fossils)], 4 miles (6.4 km.) east of Fang-lan-chön, Shan-si, China.

Collected by Eliot Blackwelder.

Anomocare subquadratum (Dames).

Plate 18, Figure 11.

Concephalites subquadratus DAMES, 1883, China, Richthofen, vol. IV, p. 12, plate 1, figs. 9, 11. (Describes and illustrates a cranidium and associated pygidia.)

Of this species we have several specimens of the cranidium and possibly the free cheeks and pygidium, but as the cranidium is associated with that of the closely related *Anomocarella butes* [plate 19, figs. 7, 7*a–d*] it is not possible to determine to which of the species they belong. The generic reference is of doubtful value.

Formation and Locality.—Middle Cambrian: (35n) Fu-chóu series, limestones near the base of the series just above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general section showing stratigraphic relations]; collected in a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria, China.

Also from Locality (C7), Lower limestone member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 39], 2.2 miles (3.5 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung.

Collected by J. P. Iddings and Li San.

Anomocare sp. undt. Walcott.

Anomocare sp. undt. WALCOTT, 1906, Proc. U. S. Nat. Mus., vol. XXX, p. 584. (Discussed as below.)

This form is represented by a fragment of the central portion of a large cephalon much like that of *Anomocare alcinoe* [plate 18, fig. 6]. The frontal limb and broad rim are similar to those of *Anomocarella temenus* [plate 20, fig. 7]. It is the youngest representative of this type of *Anomocare* as it occurs near the summit of the Cambrian system in China.

Formation and Locality.—Middle Cambrian: (C77) Limestone interbedded in green shales not more than 300 feet (90 m.) above the Man-t'o shales [Willis and Blackwelder, 1907, p. 144 (first list of fossils)], 4 miles (6.4 km.) southeast of Yau-t'o, near Wu-t'ai-hién, Shan-si, China.

Collected by Eliot Blackwelder.

Anomocare spp. (*a*), (*b*), (*c*), and (*d*).

Plate 19, Figures 3–6.

Four forms of pygidia occur in various associations that have not been referred to any described species.

One (*a*) is represented by figure 4. It occurs at Locality C64, Upper Cambrian, upper limestone member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 42 (first list of fossils), and fig. 10 (bed 20), p. 38], 2.7 miles (4.3 km.) southwest of

Yen-chuang, Sin-t'ai district, Shan-tung, China, and is associated with *Coosia ? bianos* [plate 21, figs. 10, 10*a*].

Collected by Eliot Blackwelder.

The second [(*b*) fig. 5], (C5) Middle Cambrian: Lower limestone member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 39 (first list of fossils), and fig. 8*a* (bed 30), p. 29], 3.2 miles (5.1 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung, China, is associated with *Anomocarella butes* [plate 19, figs. 7*a–d*].

Collected by Eliot Blackwelder.

The same species also occurs at Locality C8, Middle Cambrian, brown sandstone and limestone nodules in brown micaceous shales near the top of the Man-t'o formation [Blackwelder, 1907*a*, fig. 8*a* (bed 27), p. 29], 3.4 miles (5.4 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Collected by Eliot Blackwelder.

The third [(*c*) figs. 3, 3*a*], (C46) Middle Cambrian, light gray, crystalline limestone in the Ch'ang-hia limestone [Blackwelder, 1907*a*, p. 33 (fourth list of fossils)], at Ch'au-mi-tién, Shan-tung, China, is associated with *Dolichometopus dirce* [plate 22, figs. 5, 5*a–b*]. No cephalon of *Anomocare* has been found in this association.

Collected by Eliot Blackwelder.

The fourth [(*d*) fig. 6] is associated at the same stratigraphic horizon with *Levisia adrastia* and *Menocephalus agave*. Locality (C30), Middle Cambrian, layer in black oolite of the Ch'ang-hia limestone [Blackwelder, 1907*a*, p. 33 (part of first list of fossils)], 25 feet (7.5 m.) above the second cliff at an elevation of 1,700 feet (568.9 m.) on top of the long north and south ridge at Ch'ang-hia, Shan-tung, China.

Collected by Eliot Blackwelder.

Genus ANOMOCARELLA Walcott.

Anomocarella WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 54. (Genus characterized.)
Anomocarella WALCOTT, 1911, Smithsonian Misc. Coll., vol. 57, No. 4, p. 91. (Described and discussed essentially as below.)

Anomocarella was proposed to include species from the Middle Cambrian of China, that differ from *Anomocare* in the absence of glabellar furrows and the presence of a relatively narrow, flattened frontal rim. The sides of the glabella are parallel, palpebral lobes of medium size, and palpebral ridges more or less clearly defined. The associated pygidium has a narrow, conical axis, marked by several transverse furrows which extend out on the pleural lobes and more faintly on the sloping rim.

Genotype.—*Anomocarella chinensis* Walcott.

The type of this genus has ten segments in the thorax, with a broad pleural furrow that starts near the inner anterior margin of a segment, broadens very rapidly, and extends out beyond the geniculation before gradually narrowing to a point. In *Anomocarella smithi* [plate 19, fig. 16] there are twelve segments in the thorax with the same type of pleural furrow.

Anomocarella albion Walcott.

Plate 20, Figures 1, 1*a–f*.

Anomocarella albion WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 54. (Species described as below.)
Anomocarella contigua WALCOTT, 1906, idem, vol. XXX, p. 584. (Species characterized.)

This species is represented by three more or less imperfect specimens of the cephalon, exclusive of the free cheeks. These indicate that the cephalon was of moderate convexity and semicircular in outline. Glabella moderately convex, with

a gentle and nearly uniform curvature from side to side; on one specimen three pairs of glabellar furrows are very faintly indicated; the sides of the glabella arch slightly inward between the base and the rounded front; occipital furrow shallow, rounded, slightly separating from the glabella a very slightly convex occipital ring; dorsal furrow narrow but distinctly marked.

Fixed cheeks a little less than one-half the width of the glabella and nearly flat; they merge into the furrow within the palpebral lobe, and posteriorly slope gently downward to the posterior margin; palpebral ridges low, rounded, and merging into the flattened palpebral lobes; in front of the palpebral ridges the cheeks are interrupted by an obliquely transverse ridge that extends subparallel to the palpebral ridge to the front of the glabella, where it merges into the frontal limb; frontal limb very narrow, sloping rather abruptly downward from the dorsal furrow to a narrow furrow separating it from a broad, slightly downward-sloping, nearly flat frontal rim; postero-lateral limb short and marked by a shallow furrow parallel to the posterior margin.

Surface minutely punctate under a strong lens.

The largest cephalon of this species has a length of 18 mm., with a width at the palpebral lobes of 19 mm.

This large species differs from other forms by the very narrow frontal limb and the flat, downward-sloping frontal rim.

A pygidium associated with the cranidium of this species is provisionally referred to it [plate 20, fig. 1*c*]; also a somewhat similar pygidium [fig. 1*b*] from Locality C4, and a hypostoma [fig. 1*a*] from Locality C2. The three localities (C1, C2, and C4) are in the same faunal zone.

I find that *Anomocarella contigua* Walcott [1906, p. 584] was founded on fragments of *A. albion*.

Formation and Locality.—Middle Cambrian: (C1 and C2) Lower shale member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 40 (part of the third list of fossils), and fig. 10 (beds 4 and 5), p. 38], 2 miles (3.2 km.) south of Yen-chuang, and (C4) limestone nodules at the base of the lower shale member of the Kiu-lung group [idem (second list of fossils), and fig. 10 (bed 4), p. 38], 3 miles (4.8 km.) southwest of Yen-chuang, Sin-t'ai district; also (C57), limestone nodules in the lower shale member of the Kiu-lung group [idem (first list of fossils)], 3 miles (4.8 km.) south of Kao-kia-p'u, and 4 miles (6.4 km.) north of Sin-t'ai-hién, Sin-t'ai district, Shan-tung, China.

Collected by Eliot Blackwelder.

Anomocarella baucis Walcott.

Plate 20, Figures 2, 2*a*.

Anomocarella baucis WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 55. (Described as a new species essentially as below.)

This species is represented by a single specimen of about one-half of the cephalon, exclusive of the free cheeks. This specimen indicates a moderately convex cephalon, somewhat longitudinally quadrilateral in outline. Glabella moderately convex, with the sides converging slightly toward the front; surface apparently free from furrows; occipital furrow broad, shallow, slightly curving forward near the center; occipital ring low, strong, and slightly convex; dorsal furrow shallow, not clearly defined.

Fixed cheeks a little more than one-half the width of the glabella, nearly flat out to the elevated palpebral lobe and sloping with moderate rapidity to the pos-

terior margin; palpebral ridge low, narrow, and merging into the strong palpebral lobe, which is about one-third the length of the cephalon; frontal limb narrow in front of the glabella, widening at the sides in front of the palpebral ridges; it slopes gently down to a rounded, shallow furrow, that separates it from a slightly convex frontal rim which is broader than the frontal limb in front of the glabella; postero-lateral limb narrow, about as long as the width of the fixed cheek and marked by a rather strong border and shallow furrow parallel to the border.

Surface marked by scattered punctæ, and very fine punctæ visible only with the aid of a strong lens.

This species is characterized by the shallow, rounded dorsal furrow, elevated palpebral lobe, and the smooth, slightly convex frontal rim.

Formation and Locality.—Upper Cambrian: (C36) Upper part of the Ch'au-mi-tién limestone [Blackwelder, 1907*a*, p. 36 (part of third list of fossils), and fig. 9 (bed 2), p. 35], at Ch'au-mi-tién, Ch'ang-hia district, Shan-tung, China.

Collected by Eliot Blackwelder.

Anomocarella bergioni Walcott.

Plate 19, Figures 13, 13*a*.

Anomocare bergioni Walcott, 1905, Proc. U. S. Nat. Mus., vol. xxix, p. 47. (Described as a new species essentially as below.)

Cephalon, exclusive of the free cheeks, longitudinally subquadrilateral, convex. Glabella truncato-conical, moderately convex, and marked in the cast by two pairs of glabellar furrows; also a low, rounded median ridge; sides slightly arched outward opposite the palpebral lobes; front broadly rounded; occipital furrow deep, rounded, and arching forward slightly at the middle; occipital ring narrow and rising at the center to form the base of a rather strong spine; dorsal furrow strong at the sides and less so at the front.

Fixed cheeks very narrow, forming little more than a convex ridge between the dorsal furrow and the furrow within the palpebral lobe; they slope rapidly to the front, merging into the frontal limb, and posteriorly downward to a very short postero-lateral limb; palpebral lobes narrow, about one-third the length of the cephalon; palpebral ridge low and merging into the rim of the palpebral lobe; frontal limb short and sloping downward to a slightly convex frontal rim that is about twice as wide as the frontal limb in front of the glabella; the line of demarcation between the frontal limb and rim is little more than a change in direction of the slope, the slope of the rim being less.

The outer crust is exfoliated over most of the cephalon. Where preserved the outer surface is smooth under a strong lens.

The length of the cephalon of the type specimen is 12 mm.; the glabella, exclusive of the occipital groove, 6 mm.; frontal limb, 1 mm.; frontal rim, 2 mm.

This species was doubtfully referred to the genus *Anomocare*, as the glabella did not have the parallel sides so characteristic of that genus and the palpebral lobes were rather short. The reference to *Anomocarella* is based on the character of the frontal rim, the narrow fixed cheeks, and the general configuration of the glabella.

Formation and Locality.—Upper Cambrian: (C33*a*) Talus near the base of the cliff of Ch'au-mi-tién limestone [Blackwelder, 1907*a*, p. 41 (part of last list of fossils)], 9 miles (14.4 km.) north of Sin-t'ai-hién, Shan-tung, China.

Collected by Eliot Blackwelder.

Anomocarella bigsbyi (Walcott).

Plate 21, Figures 3, 3*a–b*.

Anomocare bigsbyi WALCOTT, 1906, Proc. U. S. Nat. Mus., vol. XXX, p. 581. (Described and discussed as a new species essentially as below.)

Of this species only the central portions of the cephalon, exclusive of the free cheeks, are known. Glabella moderately convex; a glabella 9 mm. in length has a width of 9 mm. at the base and 6 mm. in front; front rounded from the anterior side of the palpebral ridges; surface marked by a pair of faintly impressed posterior furrows that extend obliquely backward from the dorsal furrow toward the center; a second pair of furrows is indicated by a smooth place on the surface; occipital furrow very shallow at the center, broader and slightly deeper toward the sides, with a shallow pit near the dorsal furrow; occipital ring of medium width, very slightly convex; dorsal furrow shallow, but clearly indicated at the sides and front of the glabella.

Fixed cheeks narrow, flat opposite the palpebral lobes; they curve gently down toward the posterior furrow and more abruptly in front; palpebral lobes small, less than one-fifth the length of the cephalon; the marginal rim is prominent, and passes obliquely into the low, broad palpebral ridge which crosses the cheek obliquely to the antero-lateral angle of the glabella; frontal limb slightly concave, passing with very slight interruption into the flattened rim, the line of demarcation between the limb and rim being little more than the angle formed by the union of the sloping limb with the more nearly horizontal rim.

Surface minutely granular, the granules being irregularly distributed, and rising abruptly from the general surface. A cephalon of 15 mm. in length has the same width at the palpebral lobes.

This species may be compared with *Anomocarella temenus* [plate 20, fig. 7], from which it differs in its broader glabella and less distinctly marked line between the frontal limb and rim. The small palpebral lobe is like that of *Anomocarella bergioni* [plate 19, fig. 13].

Formation and Locality.—Middle Cambrian: (C 71) Massive cliff-making limestone in the central portion of the Ki-chóu formation [Willis and Blackwelder, 1907, pp. 139 and 145 (second list of fossils)], 4 miles (6.4 km.) southwest of Tung-yü, Shan-si, China.

Collected by Bailey Willis and Eliot Blackwelder.

Anomocarella biston (Walcott).

Plate 21, Figure 2.

Anomocare biston WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 49. (Described as a new species essentially as below.)

This species is represented by some fragments of the central portion of the cephalon. Glabella moderately convex, subquadrilateral in outline, narrowing slightly toward the broadly rounded, almost transverse front; surface marked by three pairs of slightly impressed, short furrows; occipital furrow rounded, distinctly marked, transverse; occipital ring narrow at the sides, broadening toward the center to form the base of a moderately strong spine; dorsal furrow narrow, rounded, and distinct.

Fixed cheeks narrow, scarcely more than a ridge between the dorsal furrow and the palpebral lobe; palpebral lobe about one-third the length of the cephalon, separated from the fixed cheek by a narrow, deep groove; palpebral ridge short, distinct, and merging into the rim of the palpebral lobe; postero-lateral limb about

as long as the width of the glabella, narrow, and marked by a longitudinal groove; in front of the glabella a narrow frontal limb slopes downward to a slightly convex, flattened frontal rim about three times as long as the frontal limb.

Surface minutely punctate.

Length of the largest cephalon, exclusive of the occipital spine, 8 mm.

This little species appears to be quite distinct from any other form of the genus. Its narrow fixed cheeks, relatively large eye-lobe, and flattened frontal rim are the characteristics upon which it is referred to *Anomocarella*.

Formation and Locality.—Middle Cambrian: (C2) Lower shale member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 40 (part of the third list of fossils), and fig. 10 (beds 4 and 5), p. 38)], 2 miles (3.2 km.) south of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Collected by Eliot Blackwelder.

Anomocarella butes (Walcott).

Plate 19, Figures 7, 7*a–d*.

Anomocare (?) butes WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 49. (Described as a new species essentially as below.)

General form of cephalon semicircular, moderately convex. Glabella subquadrilateral in outline, narrowing slightly toward the nearly transverse front; marked by three pairs of slightly impressed, short furrows and a low, narrow median ridge; occipital furrow shallow, rounded, and arching very slightly toward the center; occipital ring slightly convex and of moderate width throughout, marked by a minute, pointed node at the center; dorsal furrow rounded, distinct.

Fixed cheeks less than one-half the width of the glabella; they rise with a gentle slope from the dorsal furrow to the furrow within the rim of the palpebral lobe; slope back into the postero-lateral limb, and somewhat abruptly downward in front of the palpebral ridge into the frontal limb; palpebral ridge clearly defined and merging into the rim of the palpebral lobe; the latter is a little more than one-third the length of the cephalon; postero-lateral limb nearly as long as the width of the glabella at the base, narrow, and marked by a strong groove within the rounded posterior margin; frontal limb slightly convex and curving downward to the flattened frontal rim; the rim is a little longer than the length of the limb in front of the glabella, and the line of demarcation between the limb and the rim is little more than the angle formed by the union of the nearly flat rim with the inclined frontal limb.

Free cheeks irregularly triangular; marginal border flattened, strong, and produced behind into a strong, flattened spine; central area slightly convex, and rising rather abruptly to the base of the eye-lobe; anteriorly the border of the cheeks narrows to a slender point.

Thorax unknown.

Associated pygidium semicircular in outline, convex; axis convex about two-thirds the length of the pygidium, and divided by four furrows into four rings and a terminal, longer ring, upon which a slight depression on each side indicates a fifth furrow; the pleural lobes extend out about one-half of the distance nearly flat, and then curve somewhat abruptly downward to a rather broad, flattened margin, into which they merge; the four grooves on the axis and the fifth groove just within the interior margin extend across the pleural lobes, fading out on the flattened margin. Two small nodes occur at the posterior end of the axis, through which a low, broad, rounded ridge extends backward and downward into the flattened margin.

Surface minutely punctuate under a strong lens; fine, radiating, irregular, elevated lines cross the frontal limb from the furrow in front of the glabella and the palpebral ridge at the flattened frontal rim, and also from the base of the eye-lobe to the margin of the free cheeks.

This species varies from the described forms in the broad, relatively short glabella and the configuration of the frontal rim and limb. It differs from *Anomocare* (=*Conocephalites*) *subquadratum* (Dames) [1883, plate 1, fig. 9] in having a more convex glabella and frontal limb, and the front of the glabella is slightly less transverse.

Formation and Locality.—Middle Cambrian: (C5) Lower limestone member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 39 (first list of fossils), and fig. 8*a* (bed 30), p. 29], 3.2 miles (5.1 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung; also (C52), in the lower part of the lower limestone member of the Kiu-lung group [idem (second list of fossils), and fig. 7 (bed 22), p. 27], near base of cliffs in mountain 1,000 feet (305 m.) high, 3 miles (4.8 km.) north-northeast of Sin-t'ai-hién, Shan-tung, China.

Collected by Eliot Blackwelder.

Anomocarella chinensis Walcott.

Plate 20, Figures 3, 3*a–e*, 4, 4*a*.

Anomocarella chinensis Walcott, 1905, Proc. U. S. Nat. Mus., vol. xxix, p. 57. (Described as a new species essentially as below.)

Anomocare commune Lorenz, 1906, Zeitschr. deutsch. geol. Gesellsch., vol. lviii, p. 77, plate 4, figs. 10, 11, 13, 14. (Described as a new species.)

Cephalon of medium size, moderately convex, and longitudinally irregularly quadrilateral, exclusive of the free cheeks. Glabella moderately convex, rising gently from the dorsal furrow toward the center, so as to give it a slightly ridged appearance. A glabella 5 mm. in width has a length of 7 mm., exclusive of the occipital ring; surface apparently smooth; occipital furrow very slightly defined; occipital ring broad, very slightly convex, with a slight node a little in advance of the center; dorsal furrow shallow, but distinct on the sides and in front of the glabella.

Fixed cheeks about one-half the width of the glabella, slightly convex; they merge laterally into the furrows outlining the palpebral lobes, and posteriorly slope rapidly to the posterior margin; palpebral ridges low, rounded, and passing outward and merging into the narrow palpebral lobe; they clearly mark the division between the central portion of the fixed cheeks and the rapid slope to the frontal rim; palpebral lobes about one-third the length of the cephalon; frontal limb narrow in front of the glabella, widening out at the sides and sloping downward with a gentle convexity; frontal rim nearly flat, separated from the frontal limb by a shallow furrow that curves slightly backward near the center so as to form an obtuse angle. In some examples there is a slight deepening of the furrow on each side of the incurved portion of the frontal limb; postero-lateral limbs short, and marked by a rather shallow, broad furrow parallel to their posterior margin.

Thorax with ten transverse segments. Axial lobe nearly as wide as the pleural lobe exclusive of the falcate terminations of the segments, moderately convex and tapering gradually from the first to the tenth segment. Pleural lobes nearly flat for about one-half their width, and then curved gently downward; pleural furrows broad at the dorsal furrow next to the axial lobe and narrowing gradually along the outer half of their length and terminating in a long point as they curve out on the falcate ends of the pleural lobe of each segment. The ends of the pleuræ of each segment curve backward on the line of the doublure as shown in figure 4*a*.

The pygidium has a narrow, planulate margin and a rather narrow, convex axis, marked by four or five transverse furrows, which divide it into four or five rings, and a small terminal portion; the furrows extend across the pleural lobes and faintly on the margin.

Surface minutely punctate under a strong lens.

The largest specimen of the cephalon has a length of 12 mm.

This species is well represented by fragments in limestone and by entire specimens flattened in argillaceous shale, in the collection made by Prof. J. P. Iddings in Manchuria.

Anomocare commune Lorenz is illustrated by drawings of the cranidium that are identical with some of the variations of *Anomocarella chinensis* in which the arching inward of the posterior margin of the frontal border is not definitely shown. [Lorenz, fig. 10.]

Both *A. chinensis* Walcott and *Anomocare commune* Lorenz are associated with *Dolichometopus deois* Walcott [= *Bathyuriscus asiaticus* Lorenz and *Amphoton steinmanni* Lorenz].

The most nearly related form to *Anomocarella chinensis* is *A. albion* [p. 195]. The latter differs in having a proportionately shorter frontal limb and rim, and in the form of the glabella.

Formation and Locality.—Middle Cambrian: (C2) Lower shale member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 40 (part of the third list of fossils), and fig. 10 (beds 4 and 5), p. 38], 2 miles (3.2 km.) south of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Collected by Eliot Blackwelder.

Also from Locality C57, limestone nodules in the lower shale member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 40 (first list of fossils)], 3 miles (4.8 km.) south of Kao-kia-p'u, and 4 miles (6.4 km.) north of Sin-t'ai-hién, Sin-t'ai district, and (C62) earthy layer in the middle limestone of the Kiu-lung group, [idem (last list of fossils), and fig. 10 (base of bed 7), p. 38], 2.5 miles (4 km.) south of Yen-chuang, on the north-northeast spur of Hu-lu-shan, Sin-t'ai district, Shan-tung, China.

Collected by Li San.

Also from Localities 35n and 35r, Fu-chóu series, limestones near the base of the series just above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general section showing stratigraphic relations], collected in a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, and (36g) shale about 130 feet (40 m.) above the white quartzite [see idem, for general section showing stratigraphic relations], collected in drainage cuts a short distance back from the bluff [see 35n] forming the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria, China.

Collected by J. P. Iddings and Li San.

Anomocarella comus (Walcott).

Plate 19, Figures 9, 9*a*.

Ptychoparia comus Walcott, 1906, Proc. U. S. Nat. Mus., vol. xxx, p. 586. (Species described essentially as below.)

Of this species only the central portions of two small cephala are known. The glabella and fixed cheeks are convex; glabella convex, truncato-conical, and marked by three pairs of faint furrows; occipital furrow rather broad, rounded, and moderately deep; occipital ring narrow at the sides, widening gradually toward the center, where it is a little elevated above the plane of the glabella and not much wider than

the occipital furrow; dorsal furrow clearly defined on the sides and slightly marked in front of the glabella.

Fixed cheeks narrow, not over one-fourth the width of the glabella; palpebral lobes about one-third the length of the cephalon, somewhat nearer the posterior than the frontal margin of the cephalon; palpebral ridge short, and not prominent; it terminates a little back of the antero-lateral angle of the glabella; frontal limb narrow, very slightly convex, and sloping downward, with a well-defined furrow separating it from the strong, rounded, thickened frontal rim; four small, shallow pits occur in the furrow, one strong one on each side of the center, and one faint one opposite the outer edges of the glabella.

Surface finely granulose under a strong lens. The largest cephalon has a length of 5 mm.

This species is distinguished from other species of the Chinese Cambrian by its rounded, strong frontal rim, and very slightly tapering glabella, in the latter respect recalling such forms of *Anomocare* as *A. alcinoe* [plate 18, fig. 6], *A. minus* Dames [plate 19, fig. 1], and *Anomocarella butes* (Walcott) [plate 19, fig. 7] from the Cambrian of China.

Formation and Locality.—Middle Cambrian: (C71) Massive cliff-making limestone in the central portion of the Ki-chóu formation [Willis and Blackwelder, 1907, pp. 139 and 145 (second list of fossils)], 4 miles (6.4 km.) southwest of Tung-yü, Shan-si, China.

Collected by Bailey Willis and Eliot Blackwelder.

Anomocarella hermias Walcott.

Plate 20, Figures 5, 5*a*.

Anomocarella hermias Walcott, 1911, Smithsonian Misc. Coll., vol. 57, No. 4, p. 92, plate 15, fig. 10. (Described and discussed as a new species essentially as below.)

This species is represented by specimens of the cranidium having an unusually large and long palpebral lobe. This character is sufficient to distinguish it from other described species. The surface appears to be minutely punctate or marked by minute, shallow pits.

Formation and Locality.—Middle Cambrian: (35n) Fu-chóu series, limestones near the base of the series just above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general section showing stratigraphic relations], collected in a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria, China.

Collected by J. P. Iddings and Li San.

Anomocarella irma Walcott.

Plate 19, Figures 8, 8*a*.

Anomocarella irma Walcott, 1906, Proc. U. S. Nat. Mus., vol. xxx, p. 584. (Described as a new species.)

This species is represented by two specimens of the central portions of the cephalon. These indicate that the cephalon was semicircular in outline, and moderately convex. Glabella prominent, convex, sides straight and converging gently toward the front, which is broadly rounded; the only traces of glabellar furrows are two faint scars near the front, which extend from the outer margin nearly to the median line of the cephalon; occipital furrow well defined, separating a rounded, rather strong occipital ring; dorsal furrow distinctly defined at the sides and less clearly marked in front of the glabella.

Fixed cheeks narrow, almost lost in the palpebral lobes; in front of the latter they extend forward and downward, as narrow, convex ridges, merging into the frontal limb; palpebral lobes strong, about one-third the length of the cephalon; palpebral ridge merged into the fixed cheek on the back side and defined by a short, steep slope on the front side; frontal limb of medium width, sloping with very little convexity to the narrow furrow separating the frontal limb from the relatively broad, flattened frontal rim; the length of the latter in front of the glabella is a little more than that of the frontal limb.

Surface slightly roughened by elevated, irregular, more or less inosculating lines upon which numerous, minute nodes occur. The result is that on some portions the surface appears to be finely granulose, and on others finely punctate, the interspaces between the inosculating lines giving the punctate appearance and the nodes on the lines the granulose appearance. A cephalon 4.5 mm. in length has the same width at the palpebral lobes, exclusive of the free cheeks.

The nearest related species is *Lisania bura* [plate 15, fig. 15]. It differs from the latter in having a short frontal limb between the glabella and frontal rim, relatively larger palpebral lobes, and a stronger dorsal furrow about the glabella.

Formation and Locality.—Middle Cambrian: (C77) Limestone interbedded in green shales not more than 300 feet (90 m.) above the Man-t'o shales [Willis and Blackwelder, 1907, p. 144 (first list of fossils)], 4 miles (6.4 km.) southeast of Yau-t'o, near Wu-t'ai-hién, Shan-si, China.

Collected by Eliot Blackwelder.

Anomocarella macar Walcott.

Plate 20, Figures 6, 6*a–d*.

Anomocarella macar Walcott, 1911, Smithsonian Misc. Coll., vol. 57, No. 4, p. 92, plate 15, figs. 11, 11*a–b*. (Described and discussed as a new species essentially as below.)

Of the Chinese species of *Anomocarella*, the cranidium of this species may be compared with that of *A. tatian* [plate 21, fig. 1] in that the frontal limb curves more abruptly down toward the frontal margin than in most species of the genus, and the frontal margin also bends downward to a greater degree. The outline of the glabella and fixed cheeks is almost similar in the two species. The associated pygidia are more elongate than those referred to *A. tatian* and have a greater number of segments in the axial and pleural lobes.

Formation and Locality.—Middle Cambrian: (35n) Fu-chóu series, limestones near the base of the series just above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general section showing stratigraphic relations], collected in a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria, China.

Collected by J. P. Iddings and Li San.

Anomocarella smithi Walcott.

Plate 19, Figures 16, 16*a–b*.

Anomocarella smithi Walcott, 1911, Smithsonian Misc. Coll., vol. 57, No. 4, pp. 92–94, plate 17, figs. 3 and 3*a*. (Described and discussed as a new species essentially as below.)

Dorsal shield of medium size, elongate-elliptical in outline, convex, with the axial lobe strongly defined and convex. Cephalon semicircular in outline with the genal angles extended into short, sharp spines; a narrow, flattened border extends across the front of the cranidium and continues along the free cheeks until it passes into the genal spines; the posterior margin is narrow and distinctly defined by a

strong, rounded furrow that terminates in the dorsal furrow beside the glabella. Cranidium with the front broadly rounded, narrow fixed cheeks, small antero-lateral limbs, and narrow postero-lateral limbs, the greater part of which is taken up by the strong intermarginal furrow. Glabella without traces of transverse furrows except a short, slight indentation indicating a posterior pair of furrows; the glabella is separated from the fixed cheeks by a very narrow, strong dorsal furrow; the frontal limb has about the same width as the frontal margin, and extends almost directly downward from the dorsal furrow in front of the glabella to the sharp angle made by its union with the frontal margin; fixed cheeks about one-third the width of the glabella opposite the palpebral lobes, gently convex and merging into the anterior and posterior limbs; occipital ring separated from the glabella by a strong rounded furrow; it is convex, broad along the center portions and narrow toward the dorsal furrow. Palpebral lobe small, elevated, and about one-fourth the length of the cephalon; a low ridge extends from its anterior end forward and inward to the dorsal furrow beside the glabella. Free cheeks small, gently convex, and bordered by a flattened rim that is continued posteriorly into a spine; they are separated from the cranidium by the facial sutures, which cut the posterior margin a short distance within the genal angles and extend with a slight sigmoid curve inward and forward to the base of the palpebral lobes; curving around these they extend with a slight outward curvature to the angle formed by the union of the frontal limb and margin, and then curve slightly inward across the margin.

Thorax with twelve rather narrow, nearly transverse segments; axial lobe convex, with the segments slightly rounded and separated from the pleural lobes by the obtuse angle formed by the union of the two lobes; pleural lobes a little wider than the axial lobe and flattened for about half their width or to the geniculation, where each segment curves downward and slightly backward; pleural furrow relatively broad; it starts near the inner anterior edge of the pleural segment and extends along the center of the segment to the geniculation, where it gradually narrows to a point near the end of the flattened falcate termination of the segment.

Pygidium small; the subconical convex axis is marked by three shallow transverse furrows that outline three rings and a terminal section that terminates within a short distance of the posterior margin of the pygidium; pleural lobes marked by the extension of the transverse furrows on the axial lobe and the faintly indicated, rather narrow border.

Surface slightly roughened by shallow pits or a network of very minute, irregular ridges, the interspaces of which give a pitted appearance.

Dimensions.—There are nine entire specimens of the dorsal shield, exclusive of the free cheeks. The average length is 15 mm. The different parts have the following dimensions.

	mm.
Cephalon:	
Length	6.5
Width at posterior margin	9.0
Length of glabella and occipital ring	5.0
Width of glabella at base	3.5
Thorax:	
Length	7.5
Width at first segment	8.0
Width at last segment	5.0
Pygidium:	
Length	2.0
Width at anterior margin	4.5

This species is the only one of the genus *Anomocarella* of which we have specimens of the cephalon, thorax, and pygidium, with the exception of the compressed dorsal shield of *Anomocarella chinensis* [plate 20, fig. 4*a*]. The cranidium differs from that of the type of the genus, *A. chinensis* [plate 20, fig. 3], in having a relatively smaller palpebral lobe and twelve segments, instead of eight, in the thorax.

Formation and Locality.—Middle Cambrian: (90x) Conasauga formation, in and attached to the outer surface of siliceous nodules in argillaceous shales, Coosa Valley, east of Center, Cherokee County, Alabama.

Collected by A. M. Gibson, 1884, and Cooper Curtice, 1885.

Anomocarella speciosa (Lorenz).

Plate 20, Figure 8.

Anomocare speciosum LORENZ, 1906, Zeitschr. deutsch. geol. Gesellsch., vol. LVIII, pt. 2, p. 77, plate 5, figs. 6, 7. (Species characterized.)

Doctor Lorenz compares this species with his *Anomocare commune* [1906, p. 77] = *Dolichometopus deois* Walcott [p. 216]. He states that the glabella has a faint ridge passing along its median line and indistinct furrows, a small node on the occipital ring, and that the associated pygidium is typical of the genus *Anomocare*.

On plate 20, figure 8, *Anomocarella speciosa* is illustrated by photographs of the type specimen now in the collection of the University of Freiburg Museum. The comparison of the cephala of figure 8 with the cephala illustrated by figures 3 and 4 of *A. chinensis* shows that they are very much alike, but that *Anomocare commune* differs from *Anomocarella chinensis* in details of the frontal limb and margin, the proportionately wider fixed cheeks of *A. chinensis*, and more strongly marked punctate surface.

Formation and Locality.—Middle Cambrian: Limestone at Wang-tschuang, Shan-tung, China.

Anomocarella subrugosa (Walcott).

Plate 19, Figure 12.

Ptychoparia (Liostracus) subrugosa WALCOTT, 1906, Proc. U. S. Nat. Mus., vol. XXX, p. 592. (Species described and discussed essentially as below.)

This species is represented by two specimens of the cephalon, exclusive of the free cheeks. These portions of the cephalon are subrectangular in outline, strongly convex. Glabella prominent, strongly convex, with its sides converging from a width of 6.5 mm. at the base to 4 mm. at the front, in a glabella 6.5 mm. long, exclusive of the occipital furrow and ring; front arched, with a shallow pit in the dorsal furrow where the sides and front unite; the glabella is marked by three pairs of shallow, rather broad glabellar furrows, the posterior pair of which extends obliquely inward and backward about one-third the distance across the glabella; occipital furrow rounded and rather deep; occipital ring narrow and moderately convex at the sides, gradually increasing in convexity and width toward the center, where a small node occurs; dorsal furrow strong at the sides and in front of the glabella.

Fixed cheeks about half as wide as the glabella at its base, convex at the center, and sloping gently backward to the posterior furrow and more abruptly downward to the frontal limb; palpebral lobes central and small; palpebral ridge rather strong, rounded, and extending from the anterior rim of the palpebral lobe obliquely forward across the fixed cheek to a point just back of the pit at the antero-lateral angle of the glabella; frontal limb of medium width, slightly convex, and passing into the rounded furrow within the rounded, strong, convex frontal rim.

Surface with prominent, fine granulations over the glabella and fixed cheeks, with the exception of the smooth places indicating the glabellar furrows. A cephalon 10.5 mm. in length has a width of 14 mm. at the palpebral lobes.

In form this species is closely related to *Anomocarella thraso* [plate 19, figs. 14, 14*a*]. It differs in having a more convex fixed cheek and frontal rim, and in having a granulated instead of a smooth surface. From *Ptychoparia? tolus* [plate 12, fig. 13] it differs in having a proportionately more conical glabella, stronger frontal rim, and finer granulose surface.

Formation and Locality.—Middle Cambrian: (C7) Lower limestone member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 39 (last list of fossils), and fig. 8*a* (bed 33), p. 29], 2.2 miles (3.5 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Collected by Eliot Blackwelder.

Anomocarella tatian (Walcott).

Plate 21, Figures 1, 1*a–b*.

Anomocare tatian WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 53. (Species characterized essentially as below.)

This species is most closely related to *Anomocarella temenus*. It differs from it in having a proportionately more convex and broader glabella and stronger dorsal furrows. The associated pygidium is also longer in proportion to its width and it has eight or nine segments in its axis.

The largest cephalon has a length of 13 mm., exclusive of the frontal rim, which is somewhat broken. This probably had a width of about 2 mm. A glabella 10 mm. in length has a width of 8.5 mm. at the base and 7 mm. at the broadly rounded front.

Formation and Locality.—Middle Cambrian: (C23) Upper part of thin-bedded gray oolitic limestone at the base of the Ch'ang-hia formation [Blackwelder, 1907*a*, p. 32 (second list of fossils), and fig. 6 (bed 20), p. 25], 50 feet (15 m) below the base of the cliffs, 1 mile (1.6 km.) east-southeast of Ch'ang-hia, Shan-tung, China.

Collected by Eliot Blackwelder.

Anomocarella temenus (Walcott).

Plate 20, Figures 7, 7*a–d*.

Anomocare temenus WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 53. (Described as a new species.)

Anomocare ovatum LORENZ, 1906, Zeitschr. deutsch. geol. Gesellsch., vol. LVIII, p. 77, plate 4, fig. 12. (Described and illustrated as a new species.)

Cephalon large, moderately convex, and transversely quadrilateral, exclusive of the free cheeks. Glabella slightly convex, rising gently from the dorsal furrow to the center, which is marked by a narrow, longitudinal ridge. A glabella 14 mm. in length has a width of 10.5 mm. at the base and 8 mm. at the rounded frontal margin; indications of three pairs of glabellar furrows are shown by reflected light over the smooth surface; occipital furrow very shallow, scarcely more than indicating the line of demarcation between the glabella and the rather narrow occipital ring; dorsal furrow shallow.

Fixed cheeks narrow and nearly flat; they merge laterally into the large palpebral lobe and posteriorly slope down rapidly to the posterior margin; palpebral ridges low, rather broad, and clearly marking the division between the central portion of the free cheeks and the rapid slope to the frontal rim; frontal limb in front of the glabella narrower than the frontal rim; it is slightly convex and merges into the

narrow furrow between it and the rather broad frontal rim; the latter in a cephalon 21 mm. in length is 3.5 mm. long; postero-lateral limb narrow, with a length about equal to the width of the base of the glabella. A strong furrow divides it about midway, parallel to the posterior margin.

Minute scattered pores are shown on the surface under a strong lens.

The associated pygidium has a broad, planulate margin, convex axis, and slight indications of three or four segments.

The most nearly related form from China is *Anomocare planum* Dames [1883, p. 16]. This species differs from the latter in its narrower fixed cheeks and larger glabella.

Anomocare ovatum Lorenz was based on a fragment of the cranidium that is unmistakably identical with *Anomocarella temenus*.

Formation and Locality.—Middle Cambrian: (C10) Lower shale member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 40 (part of the third list of fossils), and fig. 8*a* (bed 35), p. 29], about 3 miles (4.8 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung; also (C22), Ch'ang-hia limestone in upper oolitic portion [idem, pp. 22 and 33 (part of last list of fossils)], at Ch'ang-hia, Shan-tung, China.

Collected by Eliot Blackwelder.

Also from Localities 35n and 35r, Middle Cambrian, Fu-chóu series, limestones near the base of the series just above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general section giving stratigraphic relations]; collected in a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria, China.

Collected by J. P. Iddings and Li San.

Anomocarella tenes (Walcott).

Plate 21, Figure 4.

Ptychoparia tenes Walcott, 1905, Proc. U. S. Nat. Mus., vol. xxix, p. 80. (Species described essentially as below.)

Of this species only the moderately convex central portions of the cephalon are known. Glabella prominent, moderately convex, narrowing very gradually toward the broadly rounded front; furrows only faintly indicated; occipital ring strong and bearing the broad base of a spine that extends obliquely upward and backward; occipital furrow shallow on the sides and scarcely perceptible at the center; dorsal furrow rounded and clearly defined.

Fixed cheeks slightly convex and about one-third the width of the glabella; the length of the palpebral lobes is about one-third the distance from the posterior to the front margin; palpebral ridge low, broad, and marking quite distinctly the division between the lateral fixed cheeks and the rather abrupt, downward slope of the short frontal limb, which merges into the rather broad, flat frontal rim.

Surface minutely granulose under a strong lens.

The largest cephalon in the collection has a length of about 6 mm., exclusive of the occipital spine.

This species is distinguished by the strong occipital spine, large eye-lobes, narrow fixed cheeks, and the form of the frontal rim.

Formation and Locality.—Middle Cambrian: (C28) Thin-bedded oolitic limestone at the base of the Ch'ang-hia limestone [Blackwelder, 1907*a*, p. 32 (first list of fossils), and fig. 6 (bed 20), p. 25], just above the shales in the face of the cliff, 1 mile (1.6 km.) east-southeast of Ch'ang-hia, Shan-tung, China.

Collected by Eliot Blackwelder.

Anomocarella thraso (Walcott).

Plate 19, Figures 14, 14*a*.

Ptychoparia (*Liostracus*) *thraso* WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 85. (Species described essentially as below.)

Cephalon subquadrilateral in outline, exclusive of the free cheeks, strongly convex. Glabella prominent, convex, sides straight and converging toward the front from a width of 6 mm. at base to 4 mm. at front in a glabella 6.5 mm. long; front arched, and with a pit in the furrow where the sides and front unite; three shallow, broad furrows extend nearly to the center from each side, so as to divide the surface into two narrow lobes—a terminal lobe and a strong posterior lobe; occipital furrow strong and arching forward at the center; occipital ring narrow at the sides and gradually increasing in width to the center; dorsal furrow narrow and well defined.

Fixed cheeks narrow; palpebral lobes central, and small; postero-lateral limbs short and marked by a broad, strong furrow; palpebral ridges low, but clearly defined; frontal limb short, gently convex, and sloping into a strong, rounded furrow within the rounded, narrow, prominent frontal rim.

Surface smooth under a strong lens.

A cephalon 10 mm. in length has a width of 11 mm. at the eye-lobes.

Formation and Locality.—Middle Cambrian: (C7) Lower limestone member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 39 (last list of fossils), and fig. 8*a* (bed 33), p. 29], 2.2 miles (3.5 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Collected by Eliot Blackwelder.

Anomocarella toxeus (Walcott).

Plate 19, Figures 10, 10*a*.

Ptychoparia (*Liostracus*) *toxeus* WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 83. (Species described as below.)

Of this species only the central portions of the cephalon are known. The glabella and fixed cheeks are rather strongly convex; glabella prominent, truncato-conical, without furrows, except as indicated by a slight darkening of the surface where the furows usually occur; occipital groove narrow, but very distinct; occipital ring narrow at the sides, rounded, and of medium width at the center; dorsal furrow strong, rounded, and marked by a slight pit at the antero-lateral angle of glabella.

Fixed cheeks about one-half the width of the glabella at its base; palpebral lobes small and situated about half way between the posterior and front margins; palpebral ridges faintly defined; frontal limb narrow, convex, and sloping downward to a deep, rounded groove which rises in front to a strong, rounded frontal rim; postero-lateral limbs about one-third longer than the width of the fixed cheeks; a strong furrow extends the entire distance within the posterior margin.

The surface under a strong lens appears to be smooth.

The largest cephalon has a length of 6 mm., with a width of 7 mm. at the palpebral lobes, exclusive of the free cheeks.

This species may be compared with *Anomocarella oweni* [see Walcott, 1884*b*, p. 55, plate 10, fig. 3], a form that has a wide geographic distribution in the United States, and also ranges from the Middle Cambrian into the Upper Cambrian of the Eureka district of Nevada.

Formation and Locality.—Middle Cambrian: (C28) Thin-bedded oolitic limestone at the base of the Ch'ang-hia limestone [Blackwelder, 1907*a*, p. 32 (first list of fossils) and fig. 6 (bed 20), p. 25], just above the shales in the face of the cliff, 1 mile (1.6 km.) east-southeast of Ch'ang-hia, Shan-tung, China.

Collected by Eliot Blackwelder.

Anomocarella trogus (Walcott).

Plate 19, Figure 11.

Ptychoparia (Liostracus) trogus WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 83. (Species described as below.)

Cephalon small, transversely quadrilateral, exclusive of the free cheeks, moderately convex. Glabella broadly truncato-conical and without traces of glabellar furrows; occipital furrow narrow and rather shallow, rising on the back to the rather strong, rounded occipital ring; the latter is broad through the central portions, narrowing at the sides; dorsal furrow rounded and well defined.

Fixed cheeks about one-half the width of the glabella; palpebral lobes small; palpebral ridges very faint; frontal limb very narrow, in fact it is difficult to decide that the dorsal furrow does not unite with a depressed space in front of the glabella that merges into the frontal furrow; the latter is rounded, shallow, and defines the strong, slightly convex frontal rim; postero-lateral limbs short, marked with a very distinct transverse furrow just within the posterior margin.

Surface apparently smooth under a strong lens.

This species differs from other forms in the very short frontal limb and flattened frontal rim.

Formation and Locality.—Middle Cambrian: (C25) Limestone about 50 feet (15 m.) below the Ku-shan shale in the uppermost beds of the Ch'ang-hia formation [Blackwelder, 1907*a*, p. 33 (part of the last list of fossils)], at Ch'ang-hia, Shan-tung, China.

Collected by Eliot Blackwelder.

Anomocarella tutia (Walcott).

Plate 19, Figure 15.

Ptychoparia (Liostracus) tutia WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 84. (Species described essentially as below.)

The cephalon is small, strongly convex. Glabella very convex, almost tumid; truncato-conical in outline, and without traces of glabellar furrows; occipital furrow narrow; occipital ring strong and narrow at the sides, none of the specimens show it entire at the center; dorsal furrow narrow and rather deep on the sides of the glabella, not distinctly defined in front.

Fixed cheeks about two-thirds of the width of the glabella; palpebral lobes small, with their posterior end on a line with the longitudinal center of the cephalon; palpebral ridges narrow but very clearly defined; frontal limb gently convex, rather short, and very indistinctly separated from the rather broad, almost flattened frontal rim; postero-lateral limbs strong but short; marked by a strong transverse furrow just within the posterior margin.

Surface minutely granulose.

The largest cephalon in the collection has a length of 4 mm.

This very pretty little cephalon is of the general type of *Ptychoparia ? tolus* [plate 12, fig. 13] but it differs in the greater convexity of the glabella and the form of the frontal limb.

Formation and Locality.—Middle Cambrian: (C12) Gray limestone near the top of the middle limestone member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 41 (part of the first list), and fig. 10 (bed 7), p. 38] 3.25 miles (5.2 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung; also (C19), uppermost layers of the Ch'ang-hia limestone [idem, p. 33 (part of last list of fossils)], at Ch'ang-hia, Shan-tung, China.

Collected by Eliot Blackwelder and Li San.

Anomocarella undata (Walcott).

Plate 21, Figure 5.

Ptychoparia undata WALCOTT, 1906, Proc. U. S. Nat. Mus., vol. XXX, p. 589. (Described as a new species.)

This species is represented by four specimens of the central portions of the cephalon, exclusive of the free cheeks. These show that the cephalon was semicircular in outline and rather strongly convex. Glabella convex, irregularly subquadrangular in outline; it narrows slightly from the base toward the front; the postero-lateral angles are rounded, and the anterior angles more broadly rounded into the slightly curved front; three pairs of glabellar furrows are indicated by slight depressions that extend in from the margin about one-half the distance to the median line; the posterior pair extends obliquely backward so as to indicate oval postero-lateral lobes; occipital ring rounded and strongly defined, narrow at the sides, gradually widening toward the center, which is slightly above the plane of the surface of the glabella; occipital furrow narrow, rounded, distinct, and curving slightly forward toward the center; dorsal furrow rather sharply defined at the sides and shallow in front of the glabella.

Fixed cheeks narrow and elevated into a ridge opposite the palpebral lobe, which is separated by a narrow, curved furrow; palpebral ridge low, narrow, and passing obliquely from the anterior end of the palpebral lobe to the antero-lateral angle of the glabella; postero-lateral limb narrow, about as long as the width of the front of the glabella, and marked by a rather strong furrow within an elevated, narrow posterior rim, frontal limb narrow, merging in front into the narrow, slight furrow produced by the union of the frontal limb and frontal rim; frontal rim of medium width, moderately convex, and rounding down to meet the frontal limb.

Surface appears to be minutely and irregularly punctate under a lens of moderate power. Under a strong lens it is shown to be formed by a network of irregularly inosculating, raised lines, so interrupted in places as to give a granular appearance to the surface. The largest cephalon in the collection has a length of 5 mm.

This species is most nearly related to *Anomocarella comus* [plate 19, fig. 9]; it differs in having a proportionately shorter glabella, and a more convex, thickened frontal rim. It differs from *A. thraso* [plate 19, fig. 14] in its shorter frontal limb and proportionately longer glabella.

This species is associated with *Anomocarella comus* [p. 201] and *Solenopleura pauperata* [p. 169].

Formation and Locality.—Middle Cambrian: (C71) Massive cliff-making limestone in the central portion of the Ki-chóu formation [Willis and Blackwelder, 1907, pp. 139 and 145 (second list of fossils)], 4 miles (6.4 km.) southwest of Tung-yü, Shan-si, China.

Collected by Bailey Willis and Eliot Blackwelder.

Genus COOSIA Walcott.

Coosia WALCOTT, 1911, Smithsonian Misc. Coll., vol. 57, No. 4, p. 94. (Described and discussed as a new genus essentially as below.)

The description of the genotype *Coosia superba* and the observations accompanying it may be taken as the description and discussion of the genus.

Genotype.—*Coosia superba* Walcott [1911, pp. 94–97, plate 16, figs. 1, 1*a*].

Coosia ? bianos (Walcott).

Plate 21, Figures 10, 10*a*.

Anomocare bianos WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 48. (Species described as below.)

This species is represented by a portion of the glabella and the frontal limb. The glabella appears to have been quadrilateral in outline, broadly rounded in front

and moderately convex; it is marked in the cast of the interior by very slight traces of three pairs of short glabellar furrows and a very slight, narrow median ridge; dorsal furrow shallow but well marked; frontal limb nearly flat for a distance of 2 mm. in front of the glabella, where it curves downward at an angle of about 45° for a distance of 3.5 mm. It is quite probable that at the angle between the flat portion and the sloping front there was some indication on the outer crust of a division between the two parts, if so, the shorter inner portion would be the frontal limb and the sloping outer portion the flat frontal rim. Exterior surface unknown.

This species is very clearly characterized by the form of the frontal limb. The generic reference is very doubtful.

Formation and Locality.—Upper Cambrian: (C64) Upper limestone member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 42 (first list of fossils), and fig. 10 (bed 20), p. 38], 2.7 miles (4.3 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Collected by Eliot Blackwelder.

Coosia carme (Walcott).

Plate 21, Figure 7.

Anomocarella carme WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXXIX, p. 56. (Species described as below.)

Cephalon, exclusive of free cheeks, elongate quadrilateral in outline, moderately convex. The convexity of the glabella is so slight that it is scarcely raised above the general surface of the cephalon; its outline is truncato-conical, with the front rounded; the interior cast appears to be without traces of furrows; occipital furrow transverse, narrow, rounded, and shallow; occipital ring of medium width, slightly convex; dorsal furrow lightly impressed on the sides of the glabella and scarcely perceptible in front of it.

Fixed cheeks narrow, scarcely more than a line in front of the palpebral lobes; they widen out slightly in front and merge into the frontal limb, and posteriorly into the postero-lateral limb; postero-lateral limbs narrow, length unknown; frontal limb broad, slightly convex, sloping obliquely downward and passing into the smooth, nearly flat frontal rim almost without interruption from the very shallow transverse furrow; palpebral lobes small, about one-third the length of the glabella.

The only surface markings are the fine, irregular lines that extend from in front of the glabella outward across the broad frontal limb to the frontal rim.

The type and only specimen of the cephalon in the collection is 11.5 mm. long, with a width at the palpebral lobes of 8 mm.; the glabella is 6 mm. in length; the frontal limb 2 mm.; frontal rim, 1.5 mm., and occipital ring and furrows, 2 mm.

This species has the narrow fixed cheeks, small palpebral lobes, nearly smooth glabella and broad, slightly convex, combined frontal limb and margin typical of the genus. It resembles *Anomocarella chinensis* [p. 200] in its narrow fixed cheeks and conical glabella, but it has small palpebral lobes and a convex instead of concave, combined frontal limb and margin.

Formation and Locality.—Upper Cambrian: (C38) Crystalline limestone near the base of the Ch'au-mi-tién limestone [Blackwelder, 1907*a*, p. 36 (part of first list of fossils)], at Ch'au-mi-tién, Shan-tung, China.

Collected by Eliot Blackwelder.

Coosia ? daunus (Walcott).

Plate 21, Figures 11, 11*a–c*.

Anomocare daunus WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 51. (Species characterized as below.)

This species is represented by a portion of the glabella and frontal limb, and a fragment of a large free cheek associated with it; also an associated pygidium which

has the same characteristic surface marking. Glabella slightly convex and marked by three pairs of very faintly indicated furrows; it has a length of 16 mm., with a width of 12 mm. near the base; it narrows slightly toward the rounded front. A fragment of the fixed cheek indicates that the latter was nearly flat between the glabella and palpebral lobe; the frontal lobe is nearly flat for a distance of 4 mm., when it slopes downward to the thickened frontal rim, no line of demarcation distinguishing the frontal rim.

The free cheek indicates a moderate convexity for the cephalon; also that the margin, which is very narrow at the front, widens out gradually toward the postero-lateral angle of the cephalon; the base of the eye-lobe shows that the palpebral lobe and eye were relatively small; the line of facial suture, as shown by the free cheek, shows that the postero-lateral limb of the fixed cheek was large and more than half the width of the cheek; also that the antero-lateral limb was strong.

The surface of the glabella is marked by shallow pits varying greatly in size and form; the pits are so closely crowded that the lines of the demarcation between them in places form an irregular network; on the posterior portions of the glabella, and on the frontal limb, the shallow pits are more or less scattered, giving a somewhat coarsely punctate appearance; the fixed cheeks and free cheeks are marked by strong, but not large, pits or punctæ, scattered somewhat thickly over the surface; the surface of the associated pygidium is much like that of the cheeks.

The associated pygidium has a width of 26 mm. and a length of 12 mm.; it is moderately convex, with a prominent axial lobe and a broad, slightly concave border that merges above the slightly convex pleural lobes. Axial lobe convex with the elevated portion about five-sixths of the length of the glabella; it slopes abruptly downward and backward from the elevated portion to a low, slightly convex termination near the posterior margin; divided by five well-marked transverse furrows that separate it into five segments and an obtuse terminal segment which has two rather large, rounded nodes, outlined by a slight depression at the center; the pleural lobes are grooved by the extension of the furrows crossing the axis; also by pleural grooves, both of which extend outward across the pleural lobe and curve backward across the broad, planulate border of the margin.

Formation and Locality.—Middle Cambrian: (C2) Lower shale member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 40 (part of the third list of fossils), and fig. 10 (beds 4 and 5), p. 38], 2 miles (3.2 km.) south of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Collected by Eliot Blackwelder.

Coosia decelus (Walcott).

Plate 21, Figure 8.

Anomocare decelus WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 52. (Species described as below.

Of this species only the anterior central portions of the cephalon are known. It is characterized by a broad, nearly flat, frontal rim that, with the frontal limb in front of the glabella, has a slightly convex slope interrupted only by a shallow, narrow groove; the frontal limb is ornamented with raised, narrow, irregular, more or less inosculating lines that radiate from the front of the glabella and palpebral ridges down to the narrow groove separating the limb from the frontal margin.

The fixed cheeks are about half the width of the glabella; they are nearly flat and interrupted by a rather strong palpebral ridge. The glabella is large, broadly rounded in front, with the sides subparallel from opposite the center of the palpebral

lobes to the broadly rounded front. The palpebral lobes and posterior portions of the cephalon are broken away in the only specimen known.

This species is associated with *Anomocare minus* Dames [1883, p. 15], from which it differs in the character of the frontal limb and margin, in which respects it also differs from *Anomocarella temenus* [plate 20, fig. 7] and *Anomocarella tatian* [plate 21, fig. 1]. It may also be compared with the form from the St. Croix sandstones of Wisconsin, illustrated by James Hall as "*Conocephalites diadematus*" [1863, plate 7, figs. 36, 37], from which it differs in having a convex instead of a concave frontal rim.

Formation and Locality.—Middle Cambrian: (C9) Lower limestone member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 39 (third list of fossils), and fig. 8*a* (bed 33), p. 29], 3 miles (4.8 km.) southwest of Yen-chuang, Shan-tung, China.

Coosia robusta Walcott.

Plate 21, Figures 9, 9*a*.

Coosia robusta WALCOTT, 1911, Smithsonian Misc. Coll., vol. 57, No. 4, p. 97, plate 16, figs. 2, 2*a*. (Described and discussed as a new species essentially as below.)

Of this species the cranidium and pygidium are known. The cranidium differs from that of *C. superba* [plate 21, fig. 6] in having a proportionately more elongate glabella, more convex frontal border, and narrower postero-lateral limb.

The pygidium differs in being more elongate, in having a proportionately longer axial lobe, and less flattened pleural lobes.

Formation and Locality.—Middle Cambrian: (107) Rome formation limestone at Bull Run, northwest of Copper Ridge [Keith, 1896, areal geology sheet], 11 miles (17.6 km.) northwest of Knoxville, Knox County, Tennessee.

Collected by Cooper Curtice.

Coosia superba Walcott.

Plate 21, Figures 6, 6*a*.

Coosia superba WALCOTT, 1911, Smithsonian Misc. Coll., vol. 57, No. 4, pp. 94–97, plate 16, figs. 1, 1*a*. (Described and discussed as a new species essentially as below.)

Dorsal shield large, elongate-elliptical in outline; axial lobe of medium width, conical, and narrowing from the cephalon gradually to the middle of the pygidium, where it disappears.

Cephalon semicircular in outline, moderately convex, genal angles unknown. The facial sutures cut the posterior margin some distance within the outer margin and extend inward and forward with a slight sigmoid flexure to the base of the palpebral lobe; arching about this, they extend downward and with a gentle outward curve across the frontal limb and then curve inward across the broad frontal margin. Cranidium with a rather large, subconical, moderately convex glabella that shows very slight traces of lateral furrows. Occipital ring separated from the glabella by a furrow that is rather shallow and nearly transverse; occipital ring slightly convex and of nearly uniform width. Fixed cheeks narrow, about one-fourth or less of the width of the glabella; posteriorly they merge into the large subtriangular postero-lateral limbs, which are marked by a shallow, intermarginal posterior furrow; anteriorly the fixed cheeks pass gently down and merge into the frontal limb. Palpebral lobe small, less than one-fifth the length of the cephalon; it is continued in a low ridge diagonally across the fixed cheek to the antero-lateral margin of the glabella. Frontal limb less than one-half the width of the broad, gently convex frontal border; in front of the glabella it slopes gently downward to a shallow furrow that serves to distinguish it from the frontal border. Free cheeks unknown.

Thorax with twelve rather narrow, slightly convex segments with pleural lobes that arch slightly backward; axial lobe of each segment moderately convex and unmarked, as far as known, by any tubercles or spines; at a clearly defined dorsal furrow it unites with the pleural lobe, which is about one-third wider than the axial lobe; the pleural furrows originate at the anterior inner side of the pleural segment and extend outward subparallel to the anterior margin about one-half the length of the pleural portion of the segment; the deepest portion of the furrow is just within the narrow anterior border, which is about one-fourth the width of the segment; the exterior half of the segment is gently convex and terminates in the rather bluntly rounded end which may possibly be continued backward as a very short spine or point.

Pygidium large, moderately convex, with a short, convex axial lobe and very broad, campanulate margin; axial lobe about one-half the length of the pygidium, marked by two shallow, transverse furrows that are continued out on the gentle downward slope of the pleural lobes, outlining two segments marked by short, shallow, narrow furrows; the outer portions of the pleural lobe are nearly flat or rising slightly toward the postero-lateral margins; the semicircular outline of the pygidium is interrupted toward the median axis by a slight inward curvature.

Surface slightly roughened, but not pitted or punctate, as far as can be determined. The outer half of the pleura is marked by imbricating lines subparallel to the margins of the pleura. Similar lines also occur on the flattened border subparallel to the margin of the pygidium.

The dimensions are as shown by figure 6 of plate 21.

This fine species represents a small group of species that occur in the Cambrian rocks of northern Alabama in the United States and in the Middle Cambrian rocks of the province of Shan-tung, China. The cephalon is not unlike that of *Anomocare* [plate 18] and *Anomocarella* [plates 19, 20]. It differs from the former in having small palpebral lobes and a broad, slightly convex frontal border, and from the latter in the character of its frontal border. The thoracic segments of *Coosia* are unlike those of both of the two genera mentioned in having short, slightly marked pleural furrows. The pygidium of *Anomocarella* [plate 19, fig. 16; plate 20, fig. 6*b*] is quite unlike that of *Coosia;* but the pygidium of *Anomocare* [plate 18, fig. 1*b*] has the broad, flattened margin seen in *Coosia superba* [plate 21, fig. 6].

Of the Chinese species referred to *Coosia*, *C. carme* (Walcott)* [plate 21, fig. 7] appears to be the most nearly related. *Coosis decelus* (Walcott)* [plate 21, fig. 8] has a somewhat similar frontal limb and border. Unfortunately the palpebral lobes and posterior portions of the cranidium are unknown. *Coosia (?) bianos* (Walcott)* [plate 21, fig. 10*a*] has a somewhat similar frontal limb, but with the fragments available for comparison it is impossible to make identifications of value; the same is true of the associated pygidium, of which only the central portion is known; this indicates, however, a comparatively broad margin. *Coosia ? daunus* (Walcott)* [plate 21, fig. 11] although having a similar frontal limb and form of glabella, undoubtedly belongs to a different genus or subgenus; this is indicated by its very strongly pitted surface.

A second species from Alabama, *C. robusta* [plate 21, figs. 9, 9*a*] is illustrated for comparison, as it has a well-preserved cranidium and the pygidium is proportionately more elongate than that of *C. superba*.

Another form that is very close to this species is *Coosia (?) limbata* (Angelin) illustrated on plate 21, by figures 12 and 12*a*, from the type locality at Andrarum, Sweden. *Coosia (?) limbata* differs materially, however, in having the very large

*Referred in 1905 to the genus *Anomocarella*.

eye-lobe characteristic of *Anomocare lævе* [plate 18, fig. 1] the type of the genus *Anomocare*. I think that in all probablity, with the securing of entire specimens of *C. (?) limbata*, the species will be found to have characters intermediate between *Coosia* and *Anomocare*. For the present, however, I will refer it to the genus *Coosia*, subgenus undetermined.

Formation and Locality.—Middle Cambrian: (91) Conasauga (Coosa) shales, at Cedar Bluff, Cherokee County, Alabama; (16) limestones in Conasauga (Coosa) shales, Blountsville Valley, Blount County, Alabama; and (107) limestone in Bull Run, northwest of Copper Ridge [Keith, 1896, areal geology sheet], 11 miles (17.6 km.) northwest of Knoxville, Knox County, Tennessee.

Collected by A. M. Gibson and Cooper Curtice.

Genus DOLICHOMETOPUS Angelin.

Dolichometopus ANGELIN, 1854, Palæontologia Scandinavica, pt. 1 (ed. 1878), p. 72.
Amphoton LORENZ, 1906, Zeitschr. deutsch. geol. Gesellsch., vol. LVIII, pt. 2, p. 75.

This genus is represented in China by several species. One of them, *D. deois* [plate 21, figs. 13, 13*a–d;* plate 22, figs. 1, 1*a–h*, 2, 2*a–b*], is very abundant in the form of dismembered parts of the dorsal shield; no entire specimens are known. Doctor Lorenz [1906, pp. 75–76] defines a new genus and species, *Amphoton steinmanni*, on a broken cranidium of medium size and a small cranidium [Lorenz, 1906, plate IV, figs. 15–17]. Comparing his type specimens directly with the type specimen of *D. deois* shows them to be identical. The test in some specimens is minutely punctate and on others it appears to be smooth and without punctæ.

Dolichometopus alceste Walcott.

Plate 22, Figures 3, 3*a–b*.

Dolichometopus alceste WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 94. (Species described as below.)

This species occurs at the same locality as *D. deois* [p. 216], but not in the same bed of limestone. It differs from *D. deois* in having a much more convex glabella with nearly parallel sides. Glabella marked by a posterior pair of furrows, extending inward and backward so as nearly to cut off a small, subtriangular lobe at the base of the glabella, also three pairs of short, faintly impressed furrows that extend in at right angles to the side of the glabella; occipital furrow and ring unknown; dorsal furrow shallow, but well defined.

Fixed cheeks very narrow; they slope down into the strong furrow just within the narrow palpebral lobe and anteriorly slope down to the frontal limb; the rim of the palpebral lobe crosses the narrow front cheek, forming a very short palpebral ridge; frontal limb short, nearly flat.

The exterior surface, under a strong lens, shows a few fine, scattered punctules. The inner surface of the frontal limb, where exposed by a breaking away of a portion of the shell, is strongly punctate.

The only specimen of the glabella of this species has a length of 12 mm., with a width at the palpebral ridges of 8 mm.; the frontal limb has a length of 1.5 mm.

Formation and Locality.—Middle Cambrian: (C4) In limestone nodules at the base of the lower shale member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 40 (second list of fossils), and fig. 10 (bed 4), p. 38], 3 miles (4.8 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Collected by Eliot Blackwelder.

A pygidium tentatively referred to this species is illustrated by figure 3*b*, plate 22. It is from Locality C1, Middle Cambrian, lower shale member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 40 (part of the third list of fossils), and fig. 10 (bed 4), p. 38], 2 miles (3.2 km.) south of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Collected by Eliot Blackwelder.

Dolichometopus deois Walcott.

Plate 21, Figures 13, 13*a–d;* Plate 22, Figures 1, 1*a–h*, 2, 2*a–b*.

Dolichometopus deois WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 94. (Described and discussed as a new species essentially as below.)

Bathyuriscus asiaticus LORENZ, 1906, Zeitschr. deutsch. geol. Gesellsch., vol. LVIII, pt. 2, p. 73, plate V, figs. 1–5. (Species characterized and illustrated.)

Amphoton steinmanni LORENZ, 1906, idem, vol. LVIII, pt. 2, p. 75, plate IV, figs. 15–17. (Species characterized and illustrated.)

This species is represented by the central portions of the cephalon. Glabella and fixed cheeks moderately convex; glabella prominent, moderately convex, and marked by three pairs of rather short, very faintly impressed furrows; the sides of the glabella are subparallel for a short distance near the base and then are gently inclined outward to the rounded front margin; occipital furrow shallow, rounded, and merging into the strong occipital ring; the latter is narrow at sides, broadening rather rapidly to the base of a small, backward-sloping occipital spine; in front the glabella curves rather abruptly downward, giving the anterior portion a convex appearance; dorsal furrow shallow and distinctly defined at sides of glabella.

Fixed cheeks narrow, slightly convex, and sloping posteriorly downward to an elongate postero-lateral limb; in front of the palpebral lobe the cheeks slope abruptly down to the frontal limb; palpebral lobes a little longer than one-third the length of the cephalon; there does not appear to be any definite palpebral ridge; the elevated rim of the palpebral lobe approaches closely to the dorsal furrow, where it is merged into the downward slope of the fixed cheek; frontal limb short and slightly convex.

Surface apparently smooth under a strong lens in specimens from some localities, while in others it is minutely punctate. This appears to depend somewhat on the character of the matrix and condition of preservation.

On the anterior portion of a cast of a specimen of the glabella there is indicated a very short fourth furrow close to the antero-lateral angle; the same specimen also shows what is the frontal limb in other cephala divided into a short frontal limb and a narrow, slightly upturned rim.

The largest cephalon in the collection has a length of 17 mm.

This species differs from the type of the genus, *D. svecicus* Angelin [1854, ed. 1878, p. 73], in the greater convexity of the glabella, more convex frontal limb, and other minor details of the glabella and fixed cheeks; from *D. dirce* [plate 22, fig. 5] it differs in the greater expansion of the glabella in front, and from *D. derceto* [plate 22, fig. 4] in the configuration of the frontal limb.

Bathyuriscus asiaticus Lorenz [see plate 22, figs. 2, 2*a–b*] is founded on specimens of the cranidium that are more or less flattened by compression. *Amphoton steinmanni* Lorenz is founded on small, convex cranidia. Both forms are abundantly represented among the specimens of *Dolichometopus deois* both in Shan-tung and Manchuria.

Through the courtesy of Doctor Deecke, of the University of Freiburg, I had the opportunity of directly comparing the specimens of Lorenz with the type specimens of *D. deois*.

I find in the large series of specimens in our collections that the test is finely punctate as in *Anomocare*, but that in others it is not possible to observe the punctæ. This is especially true of the specimens that have been compressed in the limestone. One of the specimens of the cephalon of this species, described by Lorenz as *Bathyuriscus asiaticus* [see plate 22, fig. 2*a*], shows both smooth and punctate surface, according to the condition of preservation.

Formation and Locality.—Middle Cambrian: (C1 and C2) Lower shale member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 40 (part of the third list of fossils), and fig. 10 (beds 4 and 5), p. 38], 2 miles (3.2 km.) south of Yen-chuang, Sin-t'ai district, and (C4) limestone nodules at the base of the lower shale member of the Kiu-lung group [idem, second list of fossils], 3 miles (4.8 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Collected by Eliot Blackwelder.

Also from Locality C19, uppermost layers of the Ch'ang-hia limestone [Blackwelder, 1907*a*, p. 33 (part of last list of fossils)], at Ch'ang-hia, Shan-tung, China.

Collected by Li San.

Also from Locality C57, limestone nodules in the lower shale member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 40 (first list of fossils)], 3 miles (4.8 km.) south of Kao-kia-p'u, and 4 miles (6.4 km.) north of Sin-t'ai-hién, Sin-t'ai district, Shan-tung, China.

Also from localities: (35o) Fu-chóu series, shales about 130 feet (40 m.) above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general section giving stratigraphic relations] collected in drainage cuts a short distance back from the bluff forming the shore of Tschang-hsing-tau Island; (35p), shales about 80 feet (24 m.) above the white quartzite [see idem], and (35r) limestones near the base of the series just above the white quartzite [see idem], the latter two collected in a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria, China.

Collected by J. P. Iddings and Li San.

Dolichometopus derceto Walcott.

Plate 22, Figures 4, 4*a*.

Dolichometopus derceto WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 95. (Described as a new species as below.)

This species is known only by the central portions of the cephalon, exclusive of the free checks. Glabella moderately convex and expanding slightly in width from the base to the rounded front; the surface is marked by two pairs of rather strong, short furrows opposite the palpebral lobe; occipital furrow strong and rather deep; occipital ring narrow at the sides, rising and widening to form the base for a small, sharp occipital spine; dorsal furrow strong on the sides of the glabella.

Fixed cheeks narrow, convex; palpebral lobe narrow, elongate, almost touching the dorsal furrow in front; postero-lateral limb of medium length, marked by a strong furrow parallel to the posterior margin; frontal limb narrow, slightly concave, and almost concealed by the overhanging, almost tumid frontal portion of the glabella.

Surface smooth under a strong lens.

The largest of the three cephala representing this species has a length of 7 mm., exclusive of the occipital spine.

Formation and Locality.—Middle Cambrian: (C1 and C2) Lower shale member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 40 (part of the third list of fossils), and fig. 10 (beds 4 and 5), p. 38], 2 miles (3.2 km.) south of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Collected by Eliot Blackwelder.

Dolichometopus dirce Walcott.

Plate 22, Figures 5, 5*a–b*.

Dolichometopus dirce WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 96. (Characterized as a new species as below.)

Only the central portions of the cephalon of this species are known. It differs from *D. deois* [plate 22, fig. 1] in the nearly parallel sides of the glabella, the absence of glabellar furrows, and the very short, almost flat, frontal limb. The occipital lobe is nearly one-half the length of the cephalon.

Surface under strong magnifier smooth.

The type specimen of the cephalon has a length of 11 mm.

Formation and Locality.—Middle Cambrian: (C24) Near top of black oolite group in the uppermost layers of the Ch'ang-hia formation [Blackwelder, 1907*a*, p. 33 (part of last list of fossils)], 2 miles (3.2 km.) east of Ch'ang-hia, Shan-tung, China.

Collected by Eliot Blackwelder.

Dolichometopus hyrie Walcott.

Plate 22, Figures 6, 6*a–b*.

Dolichometopus hyrie WALCOTT, 1906, Proc. U. S. Nat. Mus., vol. XXX, p. 594. (Described and discussed as a new species essentially as below.)

This species is represented by a single specimen of the central portions of the cephalon, and an associated free cheek and pygidium. Glabella moderately convex, with the sides slightly converging toward the broadly rounded front; glabellar furrows faintly impressed; the posterior pair extends obliquely inward and backward, obscurely outlining a subtriangular lobe on each side; also two pairs of short, faintly impressed furrows extend in at nearly right angles to the sides of the glabella; occipital furrow shallow, somewhat deeper at the sides than in the center; occipital ring narrow at the sides, widening gradually toward the center, where it is of medium width, slightly convex, and rising but little above the general surface of the glabella; dorsal furrow shallow, indicated by the union of the sloping sides and front of the glabella with the fixed cheeks and frontal limb.

Fixed cheeks narrow, nearly flat opposite the palpebral lobes, and sloping gently to the front and back; what is preserved of the palpebral lobes indicates that they were elongate, extending about one-third or more of the length of the cephalon; a narrow, slightly elevated palpebral ridge extends obliquely across the narrow fixed cheek; frontal rim short and nearly flat; the curved angle at the union of the fixed cheeks and glabella gives the impression that the frontal rim is slightly concave.

The associated free cheek is shown in figure 6*a*.

Surface, as seen by a strong lens, slightly roughened with minute granules. The type and only specimen in the collection has a length of 7.5 mm.

The associated pygidium is transverse, semicircular, and convex; axial lobe convex, a little more than three-fourths the length of the pygidium, and crossed by three rather clearly defined, narrow furrows, which differentiate three rings and a terminal portion; the outline of the axis is continued by a low swelling that extends from the end of the convex axis to the posterior margin; the furrows crossing the axis curve outward and slightly backward across the pleural lobes to the margin of the border; they are broader than the furrows on the axis and separate three rather clearly defined segments from a narrow frontal rim and a posterior portion back of the axis; border relatively narrow and sloping gently from the base of the pleural lobe to the outer margin; it arches slightly inward back of the axis. The largest specimen has a width of 26 mm., with a length of 14 mm. A small specimen 15 mm. in width has a less clearly defined border, and in other respects resembles the pygidium associated with *D. deois* [plate 22, fig. 1].

This species differs from *D. alceste* [plate 22, fig. 3] in having a proportionately longer frontal rim, less distinctly defined glabellar furrows, and in being less convex. From other described species from the Chinese Cambrian it differs in having a glabella that narrows toward the front instead of expanding. The associated pygidium is much like that associated with *D. deois* [plate 22, fig. 1*h*]. It differs in having a narrower, more clearly defined border, and more clearly defined furrows upon the pleural lobes.

Formation and Locality.—Middle Cambrian: (C69) Limestone in shales about 65 feet (19.5 m.) above base of Ki-chóu limestone [Willis and Blackwelder, 1907, p. 145 (first list of fossils)], 4 miles (6.4 km.) east of Fang-lan-chön, Shan-si, China.

Collected by Eliot Blackwelder.

Genus HYSTEROLENUS Moberg.

Hysterolenus MOBERG, 1898, Geol. Fören. Stockholm Förhandl., vol. xx, p. 318.

Hysterolenus ? spp. undt.

Plate 22, Figures 9, 9*a*; Plate 23, Figure 9.

Several pygidia occur in the collection that appear to be nearer the pygidia of this genus than to any other described. One of them from Locality C38 is illustrated by figure 9, plate 22; another from Locality C56, by figure 9*a*, and another from Locality C64 by figure 9, plate 23. The latter reference is exceedingly doubtful, as the side spine and surface are quite unlike the same features in the other specimens.

All of the specimens are from the Upper Cambrian. Those represented by figures 9 and 9*a*, plate 22, occur at the same horizon in the Ch'ang-hia limestone, and that represented by figure 9, plate 23, from a higher horizon of the same limestone.

Formation and Locality.—Upper Cambrian: (C38) Crystalline limestone near the base of the Ch'au-mi-tién limestone [Blackwelder, 1907*a*, p. 36 (part of first list of fossils)], at Ch'au-mi-tién, Shan-tung, China.

Collected by Eliot Blackwelder.

From Locality C56, lower part of Ch'au-mi-tién limestone, 25 feet (7.5 m.) below the top of Pagoda Hill [Blackwelder, 1907*a*, p. 42 (part of last list of fossils)], 1 mile (1.6 km.) west of Tsi-nan, Shan-tung, China.

Collected by Eliot Blackwelder and Li San.

From Locality C64, upper limestone member of the Kiu-lung group [Blackwelder, 1907*a*, pp. 37 and 42 (first list of fossils), and fig. 10 (bed 20), p. 38], 2.7 miles (4.3 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Collected by Eliot Blackwelder.

Genus BATHYURISCUS Meek.

Bathyuriscus MEEK, 1873. (See Walcott, 1886, Bull. U. S. Geol. Survey, No. 30, p. 215.)

Bathyuriscus manchuriensis Walcott.

Plate 23, Figures 2, 2*a–f*.

Bathyuriscus manchuriensis WALCOTT, 1911, Smithsonian Misc. Coll., vol. 57, No. 4, pp. 97–99, plate 16, fig. 4. (Described and discussed as a new species essentially as below.)

This species is founded on numerous specimens of the cranidium, free cheeks, thoracic segments, and pygidium that are compressed in a fine argillaceous shale. Unfortunately, there are no entire specimens of the dorsal shield.

As restored by combining the free cheeks and cranidium, the cephalon is semicircular in outline and moderately convex. It is bordered by a narrow, slightly rounded margin that is separated by a sharply defined narrow furrow from the glabella and the slope of the free cheeks. The posterior border is very narrow,

elevated, and separated from the fixed cheek by strongly defined furrow; the palpebral lobes are narrow and a little less than one-fourth the length of the cephalon. Genal angles extended into short, sharp, backward-curving spines. The cranidium is broad at the base, narrowing toward the front; the antero-lateral limbs are very small and disappear where the palpebral lobe touches the dorsal furrow; the postero-lateral limbs and narrow fixed cheeks merge into each other so as to form transversely subtriangular areas, with the narrow palpebral lobes on their front outer margins.

Glabella large, subquadrangular in outline, and separated from the fixed cheeks by clearly defined dorsal furrows; its sides are nearly parallel or slightly diverging; front broadly rounded, almost transverse; surface marked by five pairs of furrows, the posterior of which extends obliquely across the posterior portion nearly to the center and separates a small triangular lobe on each side; the next two anterior pairs of furrows are short and extend inward at right angles to the side of the glabella; the anterior pair is nearly opposite the front end of the palpebral lobe; the anterior furrows are short and extend obliquely inward subparallel to the front margin of the glabella. Occipital ring narrow at the sides, widening toward the center, where it is marked by a small sharp node a little back of the transverse center. Free cheeks large and surmounted on the inner side by a narrow eye-lobe. The facial sutures cut the posterior margin a little within the genal angle and extend obliquely inward and lightly forward to the base of the eye-lobes; curving over and around the eye-lobes, they extend forward and downward, cutting the front margin on a line with the posterior base of the eye-lobe. Number of thoracic segments unknown. Single specimens of the segments show that the axial lobe was nearly as wide as the pleural lobes, that it was moderately convex, and that a small node occurs at the center of each segment near the posterior margin; also that on the outer side of each segment a rounded transverse node is outlined from the main body of the segment by a slightly oblique transverse furrow; pleural lobes nearly flat out to the geniculation, where they curve gently downward; each pleura has a furrow that is broad at its inner end next to the axial lobe and gradually narrows to the geniculation, where it terminates within the somewhat broadly rounded outer extremity; in well-preserved specimens a rounded ridge starts near the inner end of the pleural furrow and extends outward one-fourth of the length of the furrow.

The associated pygidia are semicircular, with the anterior margin almost transverse in the compressed specimens. The axial lobe is large and quite distinctly marked; it is divided by three transverse furrows into three rings and a terminal section that ends posteriorly just within the outer border; a small node occurs near the posterior margin at the center of each ring; five anchylosed segments are outlined on the pleural lobes by furrows that progressively curve more and more backward from the first to the posterior one, which adjoins the terminal segment; the furrows all terminate within the narrow, slightly flattened border.

The casts of the outer surface indicate that it was smooth or minutely granulose.

This species appears to be quite distinct from any that has been described. The quadrangular glabella with nearly parallel sides distinguishes it from *Bathyuriscus howelli* Walcott [1886, plate 30] and *B. productus* Hall and Whitfield [idem, fig. 1], which is illustrated on the same.

Formation and Locality.—Middle Cambrian: (350, 36g, and 36h). Fu-chóu series, shales about 130 feet (40 m.) above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general section giving stratigraphic relations]; collected near a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liautung, Manchuria, China.

Collected by J. P. Iddings and Li San.

Genus ASAPHISCUS Meek.

Asaphiscus MEEK, 1873. (See Walcott, 1886, Bull. U. S. Geol. Survey, No. 30, p. 219.)

Asaphiscus iddingsi Walcott.

Plate 23, Figures 1, 1*a–b*.

Asaphiscus iddingsi WALCOTT, 1911, Smithsonian Misc. Coll., vol. 57, No. 4, pp. 99–101, plate 16, fig. 3. (Described and discussed as a new species essentially as below.)

Dorsal shield longitudinally oval in outline, moderately convex. Cephalon semicircular in outline; a little more than one-third of the entire length of the dorsal shield; bordered by a nearly flat or slightly rounded margin that passes at the genal angle into a moderately strong genal spine; within the genal spine a rounded posterior border is separated from the fixed cheek by a rounded, clearly defined furrow; the intermarginal furrow is shallow and rounded. Cranidium moderately convex and roughly subquadrate in outline; the frontal limb is slightly convex and, with the anterior portion of the glabella and the front margin, forms a gentle slope that is broken only by the slight dorsal furrow in front of the glabella and the shallow intermarginal furrow; the frontal limb merges on the sides into the fixed cheeks, which are a little less than one-half the width of the glabella; posteriorly the fixed cheeks merge into relatively small postero-lateral limbs; palpebral lobe narrow and extended in front as a low ridge that crosses the fixed cheek to the dorsal furrow near the antero-lateral angle of the glabella; that portion of the palpebral lobe above the eye is about one-fourth the length of the cephalon.

Glabella large, slightly narrower in front than at the occipital furrow; sides nearly straight and slightly converging, frontal margin broadly rounded; surface marked by very faint impressions of three pairs of glabellar furrows, which can only be seen where the surface is very perfectly preserved. Occipital ring about as wide as the frontal margin and separated from the glabella by a shallow furrow that terminates on the side slightly in advance of the posterior intermarginal furrow. Free cheeks about as wide opposite the eye as the fixed cheeks; eye-lobe about one-fourth the length of the cephalon. Postero-lateral angle continued backward into a moderately strong spine. The facial sutures cut the posterior margin just within the genal angle and extend obliquely inward with a slightly sigmoid curvature to the base of the eye-lobes; curving over and around the eye-lobes, they pass forward and a little outward, cutting the frontal margin obliquely.

Thorax with nine segments; axial lobe moderately convex, slightly narrower than the pleural lobes in compressed specimens; on the outer side of each segment a low, rounded node or ridge is separated from the main body of the segment by a slightly oblique furrow transverse to the segment; pleural lobes slightly convex, nearly flat out to the geniculation, where they curve slightly downward and backward; each pleura has a well-defined furrow starting near the inner anterior margin and extending backward to the center of the pleura at the geniculation, where it curves slightly backward and terminates on the broadly rounded, slightly falcate end of the pleura.

Pygidium roughly semicircular in outline, one-fourth the length of the dorsal shield; anterior margin nearly transverse at the axial lobe and curving slightly backward to conform to the curvature of the last thoracic segment; axial lobe moderately convex and tapering gradually toward its posterior section, which is just within the nearly flat marginal border; it is divided by four transverse furrows into four rings and a terminal section; three anchylosed pleural segments are outlined on the pleural lobes by furrows that curve backward and terminate on the inner margin of the doublure; this line is continued forward on the pleural lobes of the thorax, terminating on each side opposite the posterior end of the facial suture.

Surface of specimens preserved in the limestone nearly smooth or marked by very minute shallow pits.

Dimensions.—A dorsal shield 30 mm. in length has the following dimensions:

	mm.
Cephalon:	
Length	11.0
Length of eye-lobe	3.5
Width at posterior margin	20.0
Width of glabella at posterior margin	6.0
Thorax:	
Length	12.0
Width at fourth segment	19.0
Width of axial lobe at first segment	5.5
Width of axial lobe at ninth segment	4.0
Pygidium:	
Length	7.0
Width at union with thorax	12.0

Fragments of this species are quite abundant in the limestones and interbedded shales. A few entire specimens are found in a fine argillaceous shale a short distance above the white quartzite at the base of the section, and it is from the best specimens of these that the above description was drawn, together with specimens of the cranidium in the limestone.

In general outline and appearance *Asaphiscus iddingsi* approaches the type of the genus, *A. wheeleri* Meek [Walcott, 1886, plate 31, fig. 3]. *Asaphiscus iddingsi* has a genal spine, a longer eye-lobe, a proportionately shorter cephalon, and nine, instead of eight, segments in the thorax.

Formation and Locality.—Middle Cambrian: (35r and 36e) Fu-chóu series, shales interbedded with limestones near the base of the series just above the white quartzite [see Blackwelder, 1907*b*, p. 92, for general section giving stratigraphic relations]; collected in a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria, China.

Collected by J. P. Iddings and Li San.

Genus ILLÆNURUS Hall.

Illænurus canens Walcott.

Plate 23, Figures 3, 3*a–c*.

Illænurus canens WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 96. (Described as a new species essentially as below.)

Cephalon, exclusive of the free cheeks, subrhomboidal in outline, moderately convex. Glabella subquadrate, moderately convex, length and width the same, without perceptible occipital or dorsal furrows; palpebral lobes small, with their anterior end opposite the center of the glabella; frontal margin broadly rounded; postero-lateral limbs short and subtriangular in outline; the facial suture, cutting the frontal rim on a line with the base of the palpebral lobe, passes directly to the anterior margin of the palpebral lobe; it encircles the latter, and then, curving gently outward, passes in an almost direct line to the postero-lateral margin of the postero-lateral limb.

Surface minutely punctate under a strong lens.

The pygidia associated with the cephalon parts are rounded subtriangular in outline, and about two-thirds as long as the width of the anterior margin, rather convex, and marked on the interior of the cast by a faintly defined, rather narrow axis, and very slight traces of ten or more transverse furrows on the axis, that are more faintly indicated for a short distance on the pleural lobes.

The largest cephalon in the collection has a length of 14 mm., with the same width at the palpebral lobes; a pygidium 14 mm. in length has a width of 20 mm.

This species appears to be most nearly related to *Illænurus eurekensis* Walcott [1884*b*, p. 97, plate 12, figs. 4, 4*a*], which occurs at the base of the Ordovician in the Eureka district of Nevada, but it differs in the smaller palpebral lobes, which are situated farther back on the cephalon; and it differs from *I. ceres* [plate 23, fig. 4] in its proportionately longer cephalon.

The species is widely distributed in the Upper Cambrian limestone.

Formation and Locality.—Upper Cambrian: (C38) Crystalline limestone near the base of the Ch'au-mi-tién limestone [Blackwelder, 1907*a*, p. 36 (part of the first list of fossils)], at Ch'au-mi-tién; (C34) purplish-gray limestone about 100 feet (30 m.) above the base of the Ch'au-mi-tién formation [idem], in road at northeastern corner of small village near Ch'au-mi-tién; (C42) in the central part of the Ch'au-mi-tién limestone [idem (second list of fossils)], 1.8 miles (2.9 km.) west-southwest from the temple on Tsing-lung-shan, 7.5 miles (12 km.) east of Ch'au-mi-tién, and (C41) lower part of the Ch'au-mi-tién limestone [idem (part of the first list of fossils)], 2.7 miles (4.3 km.) southwest of Ch'au-mi-tién, Shan-tung; also (C54), lower part of Ch'au-mi-tién limestone [idem, p. 42 (part of last list of fossils)], near top of limestone knoll two-thirds of a mile (1.1 km.) west of Tsi-nan, Shan-tung, China.

Collected by Eliot Blackwelder.

Illænurus ceres Walcott.

Plate 23, Figures 4, 4*a*.

Illænurus ceres WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 97. (Described as a new species essentially as below.)

Cephalon, exclusive of the free cheeks, rounded subquadrate, moderately convex; the posterior margin of the cephalon curves slightly upward opposite the glabella, where there is a slight thickening which gives the appearance of a narrow occipital ring; the front margin of the cephalon is broadly curved. Glabella very faintly outlined on the interior of the cast; as thus shown it has a width at the base of 6 mm. and at the front of 4.5 mm. on a cephalon 11 mm. in length; its somewhat rounded front is about 1 mm. from the frontal rim of the cephalon; no traces of glabellar furrows have been observed, and in only one specimen can the very faint dorsal furrow that outlines the glabella be seen.

Fixed cheeks of the same specimen 3 mm. in width at the palpebral lobes, from which they extend with almost uniform width to the front, and broaden slightly backward before merging into the short, triangular postero-lateral limbs; palpebral lobes small and situated back of a line passing through longitudinal center of cephalon.

The associated pygidium in the same fragment of rock is rounded subtriangular in outline, moderately convex, and without any indication of an axis except a very narrow, slightly marked median ridge on the cast of the interior. A specimen 11 mm. in length has a width of 16 mm. at the front margin; a very slight elevation of the front margin near the center indicates that the axial lobe of this specimen had a width of about 6 mm.

Surface minutely but not closely punctate under a strong lens.

This species differs from *I. canens* by the greater width of the cephalon at the palpebral lobes and less convexity; the associated pygidium is less convex, more subtriangular in outline, and without the indication of a central axis.

The associated species on the same hand specimen are *Ptychaspis ceto* and *Coosia carme*.

Formation and Locality.—Upper Cambrian: (C38) Crystalline limestone near the base of the Ch'au-mi-tién limestone [Blackwelder, 1907*a*, p. 36 (part of first list of fossils)], at Ch'au-mi-tién, Shan-tung, China.

Collected by Eliot Blackwelder.

Illænurus dictys Walcott.

Plate 23, Figures 5, 5*a*.

Illænurus dictys WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 98. (Described as a new species essentially as below.)

Cephalon, exclusive of the free cheeks, rounded, subquadrate, gently convex; the posterior margin of the cephalon curves slightly upward opposite the central portion, where there is a slight elevation which gives the appearance of a narrow occipital ring; the front margin of the cephalon is broadly rounded, with a very broad, obtuse angle at the center; the cast of the interior of the crust shows a very faint, low, longitudinal median ridge. The glabella is not defined from the fixed cheeks. The palpebral lobes are small and situated nearly opposite the center of the cephalon; postero-lateral limbs small and short.

Surface smooth under a strong lens.

The associated pygidium is transverse, rounded, subtriangular; front broadly rounded; sides gently rounded, forming a rounded obtuse angle at the posterior margin; the cast of the interior of the crust shows a narrow, slightly defined axis, with eight or more very faint transverse furrows and rings. The pleural lobes are gently convex and without any trace of furrows.

A cephalon of 6 mm. in length has an equal width at the palpebral lobes. A specimen of the associated pygidium 7 mm. in length has a width of 8 mm. at the frontal margin.

This species differs from *Illænurus ceres* [p. 223] in the obtusely pointed frontal margin of the cephalon and its less convexity. From *Illænurus canens* [p. 222] it differs in the direction of the facial sutures from the frontal margin back to the palpebral lobes; the sutures of *Illænurus dictys* extend slightly outward from the base of the palpebral lobe to the margin, while those of *Illænurus canens* extend directly forward, making the central portion of the cephalon narrower at the frontal margin.

Formation and Locality.—Upper Cambrian: (C56) Lower part of Ch'au-mi-tién limestone, 25 feet (7.5 m.) below the top of Pagoda Hill [Blackwelder, 1907*a*, p. 42 (part of last list of fossils)], 1 mile (1.6 km.) west of Tsi-nan, Shan-tung, China.

Collected by Eliot Blackwelder and Li San.

SEPARATED PYGIDIA.

There are several genera and a number of species represented in the collections by pygidia which can not readily be referred to any known cephala. It is thought best to indicate such by generic reference as far as possible, but not to give specific names, thus avoiding duplication where the cephala of the same species may have been described from other localities and by other authors. Where the separated pygidia are associated with cephala considered to belong to the same genus, they are placed next to the cephala on the plate, and notes made of their relations in the description of the plate.

There are also a number of free cheeks which are not associated with the central portions of the cephalon of any species to which they can be assigned. A number of these have been generically identified, and will be referred to in the description of the plate upon which they are figured.

OSTRACODA.

Genus ALUTA Matthew.

Aluta bergeroni (Walcott).

Plate 23, Figure 10.

Bradoria bergeroni WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 99. (Species described as below.)

General outline broadly semielliptical. Hinge-line straight, nearly as wide as the breadth of the valve; anterior cardinal angle about 80°; posterior cardinal angle slightly obtuse; the anterior margin is very slightly curved from the angle to where it merges into the broadly rounded front; posterior margin somewhat broadly rounded from the angle to the front. Surface convex, the greatest convexity being back of the transverse center between the ocular tubercle and the posterior fourth of the valve. From this elevated portion the surface slopes rapidly and somewhat abruptly to the hinge-line and more gently to the lower margin. From the anterior cardinal angle a very short, narrow ridge extends to a small, circular, slightly elevated tubercle which is situated about an equal distance from the hinge-line and the anterior margin. The anterior, posterior, and lower margins have a narrow, rounded rim that is slightly flattened on the inner side.

Surface marked by shallow, scattered punctæ and very fine punctæ, as seen under a strong lens.

Width of valve, 1.8 mm.; length, 1 mm.; depth, about 0.5 mm.

This species is distinguished from *Aluta sterope* [p. 227] by its greater width and the form of the ocular tubercle.

Formation and Locality.—Middle Cambrian: (C32) A fine-grained bluish-black limestone bowlder believed to have come from the lower part of the Ki-sin-ling limestone [Blackwelder, 1907*c*, p. 272]; collected in river drift 1 mile (1.6 km.) south of Chön-p'ing-hién, on the Nan-kiang River, southern Shen-si, China.

Collected by Bailey Willis and Eliot Blackwelder.

Aluta enyo (Walcott).

Plate 23, Figure 11.

Bradoria enyo WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 99. (Species described as below.)

General outline irregularly oval. Hinge-line about four-fifths the width of the valve; anterior cardinal angle nearly a right angle; posterior cardinal angle slightly obtuse; the anterior margin extends from the angle almost directly downward to where it curves and merges into the broadly rounded lower margin; posterior margin very slightly rounded from the angle downward to where it curves and merges into the lower margin. Surface moderately and uniformly convex, the highest portion being near the center; a very short, narrow, low, and somewhat obscure ridge extends obliquely inward from the anterior cardinal angle to a small, slightly elevated ocular tubercle; a slight furrow appears to extend from the tubercle obliquely to a point about midway of the hinge-line; a little posterior to this, and near the hinge-line, there appears to be a minute, low tubercle.

The surface appears to be minutely punctate under a strong lens.

Width of valve, 1 mm.; length, 0.75 mm.; depth, about 0.25 mm.

This species is distinguished from *A. sterope* [p. 227] by the difference in the form of the anterior cardinal angle and the position of the ocular tubercle. The

latter is in about the same position as the tubercle on *A. bergeroni* [p. 225] but *A. bergeroni* is quite different in its outline and convexity.

Formation and Locality.—Middle Cambrian: (C32) A fine-grained bluish-black limestone bowlder believed to have come from the lower part of the Ki-sin-ling limestone [Blackwelder, 1907*c*, p. 272]; collected in river drift 1 mile (1.6 km.) south of Chön-p'ing-hién, on the Nan-kiang River, southern Shen-si, China.

Collected by Bailey Willis and Eliot Blackwelder.

Aluta eris (Walcott).

Plate 23, Figure 12.

Bradoria eris WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 100. (Species described as below.)

General outline obliquely semicircular. Hinge-line straight; anterior cardinal angle about 70°; posterior cardinal angle slightly obtuse; anterior margin nearly straight to where it merges into the rounded lower margin; posterior margin gently rounded from the angle down to where it merges into the lower margin. Surface moderately convex, with the highest point at the tubercle a little in front of the center; a very narrow rim extends from the posterior cardinal angle around to the anterior side, where it broadens out and continues to the anterior cardinal angle; a slight, narrow ridge extends obliquely inward a short distance from the anterior cardinal angle to a furrow that extends from the hinge-line at right angles a short distance; the ridge and furrow outline a small lobe; from the inner angle, formed by the furrow and ridge described, a very narrow ridge extends downward, subparallel to the anterior margin, to the base of a strong, elevated tubercle or spine that is situated on the anterior third a little in advance of the transverse center of the valve.

Under a strong lens the surface appears to be slightly roughened by shallow punctæ.

Width, 2 mm.; length, 1.5 mm.; depth, about 0.5 mm.

This species differs from *Aluta sterope* [p. 227] in the outline of its valve and the presence of an elevated tubercle near the center.

Formation and Locality.—Middle Cambrian: (C32) A fine-grained bluish-black limestone bowlder believed to have come from the lower part of the Ki-sin-ling limestone [Blackwelder, 1907*c*, p. 272]; collected in river drift 1 mile (1.6 km.) south of Chön-p'ing-hién, on the Nan-kiang River, southern Shen-si, China.

Collected by Bailey Willis and Eliot Blackwelder.

Aluta fragilis (Walcott).

Plate 23, Figure 13.

Bradoria fragilis WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 100. (Species described as below.)

Hinge-line nearly straight, about one-fifth shorter than the width of the valve; posterior cardinal angle obtuse, with the marginal curve long and passing into the broad curve of the lower end of the valve; anterior cardinal angle about 75°, with the anterior margin nearly straight to where it merges into the broad curve of the lower part of the valve. Surface of the valve wrinkled to such an extent that it looks like wrinkled parchment. What may be an ocular tubercle occurs a short distance from the hinge and anterior margin.

Surface minutely punctate under a strong lens.

Width, 2.25 mm.; length, 2 mm.; depth, unknown, as the flexible test has been compressed.

This species differs from *Aluta flexilis* Matthew [1896, p. 198] in having a straight hinge-line; in this respect it resembles some forms of *Leperditia*. For the present it is referred to *Aluta* on account of its close resemblance to *Aluta sterope*.

The specimens were collected from a fragment of compact, bluish-gray, thin-bedded limestone containing fragments of a trilobite that suggests *Dorypyge*.

Formation and Locality.—Middle Cambrian: (C32) A fine-grained bluish-black limestone bowlder believed to have come from the lower part of the Ki-sin-ling limestone [Blackwelder, 1907*c*, p. 272]; collected in river drift 1 mile (1.6 km.)south of Chön-p'ing-hién, on the Nan-kiang River, southern Shen-si, China.

Collected by Bailey Willis and Eliot Blackwelder.

Aluta sterope (Walcott).

Plate 23, Figure 14.

Bradoria sterope WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 101. (Species described as below.)

Outline of shell obliquely semicircular. Hinge-line straight, nearly as long as the width of the valve; anterior cardinal angle about 80°; anterior curve obsolete; from the anterior cardinal angle the margin slopes downward and slightly inward, curving gently into the broadly rounded lower margin; posterior cardinal angle slightly obtuse; posterior margin curves gently from the angle to the broad curve of the lower side of the valve, which gives a broadly rounded posterior end. The valve is rather strongly convex, rising to the greatest height near the center. The surface is marked by a very narrow rim; from the anterior cardinal angle a narrow ridge extends obliquely inward about one-half the distance toward the center, and terminates in a slight tubercle; on the anterior side there are three shallow depressions, as though the surface had been indented; on the posterior side there is one larger depression directly back of the tubercle at the end of the ridge, and a slight depression in the angle formed by the palpebral ridge, the hinge-line and the ridge between the two depressions.

Surface with minute scattered punctæ, as seen under a strong lens.

The valve has a width of 1.125 mm.; length, 0.8 mm.; depth, about 0.25 mm.

In outline this species resembles *Aluta fragilis* [p. 226]; it differs in its stronger shell and distinctly marked ridge and ocular tubercle.

Formation and Locality.—Middle Cambrian: (C32) A fine-grained bluish-black limestone bowlder believed to have come from the lower part of the Ki-sin-ling limestone [Blackwelder, 1907*c*, p. 272]; collected in river drift 1 mile (1.6 km.) south of Chön-p'ing-hién, on the Nan-kiang River, southern Shen-si, China.

Collected by Bailey Willis and Eliot Blackwelder.

Aluta woodi (Walcott).

Plate 23, Figure 15.

Bradoria woodi WALCOTT, 1905, Proc. U. S. Nat. Mus., vol. XXIX, p. 102. (Species described as below.)

Outline of shell obliquely semicircular. Hinge-line straight, a little shorter than the greatest width of the shell; anterior cardinal angle about 70°; posterior cardinal angle obtuse; the posterior margin has a gentle curvature from the angle, which gives it a broadly rounded outline down to where it merges into the broadly rounded lower side; anterior margin almost straight and then gently curving into the lower margin. Surface rather convex, with the highest portion at the ridge around the central depression; the outer rim is very narrow and slightly rounded; from the anterior cardinal angle a narrow, sharp ridge extends obliquely inward

and forward to a little below the center and arches around a rather large, depressed central space, terminating a short distance before completing a circuit of the space; between the ridge described and the hinge-line are two spaces outlined by the main ridge; of these the one nearest the anterior cardinal angle is somewhat depressed and outlined by a shallow furrow extending at right angles to the hinge-line from the ridge to the hinge-line. At a point about two-thirds the distance of the length of the hinge-line a short and very slight ridge extends toward the hinge-line from the main ridge; between this and the slight furrow there is a slightly convex area. Two minute tubercles occur on the long central ridge, one at the point where it begins the loop to inclose the depressed central space and the other on the opposite side of the depressed space.

Surface minutely punctate under a strong lens.

Entire width of valve, 2 mm.; length, 1.25 mm.; depth, about 0.5 mm.

This species is distinguished from *Aluta sterope* [p. 227] by its wider valve and the presence of the central ridge and depressed space.

The specific name is given in recognition of the excellent and thorough preparatory work that was done by Miss Elvira Wood in the preliminary study of the Cambrian fossils from China and her work upon the Devonian crinoids.

Formation and Locality.—Middle Cambrian: (C32) A fine-grained bluish-black limestone bowlder believed to have come from the lower part of the Ki-sin-ling limestone [Blackwelder, 1907*c*, p. 272]; collected in river drift 1 mile (1.6 km.) south of Chön-p'ing-hién, on the Nan-kiang River, southern Shen-si, China.

Collected by Bailey Willis and Eliot Blackwelder.

MEROSTOMATA.

Genus AMIELLA Walcott.

Amiella Walcott, 1911, Smithsonian Misc. Coll., vol. 57, No. 2, p. 27. (Described and discussed as a new genus.)

Amiella yunnanensis Mansuy (MSS).

After the printing of the paper on Middle Cambrian Merostomata,[1] I received under date of March 22, 1911,[2] a letter from Dr. H. Mansuy, geologist of Indo-China, in which he stated that he had proposed the specific name *yunnanensis* for the merostome associated with *Redlichia chinensis*. Doctor Mansuy also sent a photograph of the illustration which will appear in his forthcoming report.

[1]Smithsonian Misc. Coll., vol. 57, No. 2, 1911.

[2]Received at Washington in May, 1911.

Description of Plate 1.

Globigerina ? mantoensis Walcott (p. 59).

1. Exterior view of a bilobed specimen, × 8. From Locality C 5, Middle Cambrian, Kiu-lung group, southwest of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 57613.

Protospongia chloris Walcott (p. 59).

2 and 2*a*. Spicules showing form and lines of separation of inner and outer portions of rays, × 6. From Locality C 4, Middle Cambrian, Kiu-lung group, southwest of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. Nos. 57614 and 57615.

Coscinocyathus elvira Walcott (p. 60).

3. Exterior view of a small cup, × 8. U. S. Nat. Mus., Cat. No. 57724.

3*a*. A fragment of cup greatly enlarged to show poriferous outer surface, × 8. U. S. Nat. Mus., Cat. No. 57725.

3*b*. Oblique section of portion of small cup showing poriferous wall, and cross-sections of walls of cup toward apex, × 8. U. S. Nat. Mus., Cat. No. 57726.

3*c*. Enlargement of partly abraded surface where it is divided into slightly irregular squares by radiating septa and concentric dissepiments. U. S. Nat. Mus., Cat. No. 57727.

The specimens illustrated by figs. 3, 3*a–c* are from Locality C 75, Middle Cambrian, Ki-chóu formation, south of Wu-t'ai-hién, Shan-si.

Protospongia sp. undt. Walcott (p. 60).

4. Spicule showing the character of the spicule, × 6. From Locality 35 n, Middle Cambrian, Fu-chóu series limestone, Liau-tung, Manchuria. U. S. Nat. Mus., Cat. No. 57728.

Planolites sp. undt. Walcott (p. 61).

5. View of specimen described. Natural size. From Locality 36 f, Middle Cambrian, Fu-chóu series, Liau-tung, Manchuria. U. S. Nat. Mus., Cat. No. 57732.

Micromitra sculptilis (Meek) (p. 61).

6. Summit and side views of a ventral valve, × 6. U. S. Nat. Mus., Cat. No. 57729.

6*a*. Exterior of dorsal valve, × 6. U. S. Nat. Mus., Cat. No. 57730.

The specimens represented by figs. 6 and 6*a* are from Localities 35 n and 35 r, Middle Cambrian, Fu-chóu series in limestone, Liau-tung, Manchuria.

Micromitra (Paterina) lucina Walcott (p. 62).

7. Summit, side, and back views of a ventral valve, × 6. U. S. Nat. Mus., Cat. No. 57559.

7*a*. Exterior of a dorsal valve, × 6. U. S. Nat. Mus., Cat. No. 57731.

The specimens represented by figs. 7 and 7*a* are from Locality 35 r, Middle Cambrian, Fu-chóu series in limestone, Liau-tung, Manchuria.

Micromitra (Paterina) labradorica orientalis (Walcott) (p. 62).

8. Exterior view of type specimen of dorsal valve, × 4. From Locality C 9, Middle Cambrian, Kiu-lung group, southwest of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 52516.

Micromitra (Iphidella) pannula maladensis (Walcott) (p. 63).

9 and 9*a*. Summit view and side outline of a ventral valve, × 6. Locality 35 n, Middle Cambrian, Fu-chóu series limestone, Liau-tung, Manchuria. U. S. Nat. Mus., Cat. No. 57733.

Micromitra (Iphidella) pannula ophirensis (Walcott) (p. 63).

10, 10*a*, and 10*b*. Top, side, and back views of a partly exfoliated ventral valve, × 4. Locality 35 n, Middle Cambrian, Fu-chóu series in limestone, Liau-tung, Manchuria. U. S. Nat. Mus., Cat. No. 57735.

Obolus chinensis (Walcott) (p. 64).

11. Partly exfoliated, broad form of ventral valve, × 6. U. S. Nat. Mus., Cat. No. 52532*a*.

11*a*. Interior of narrow form of ventral valve, × 6. U. S. Nat. Mus., Cat. No. 52532*b*.

11*b*. Partly exfoliated dorsal valve, showing visceral area and central muscle scars (*h*), × 6. U. S. Nat. Mus., Cat. No. 52532*d*.

The specimens illustrated by figures 11, 11*a–b* are from Locality C 62, Middle Cambrian, Kiu-lung group, argillaceous limestone, south of Yen-chuang, Shan-tung.

11*c*. Enlargement to 2 diameters of a portion of a slab of limestone on which several ventral and dorsal valves of this species occur. [For further illustration see Walcott, 1912*b*, plate XXXIX, figs. 7 *a–b*.] Locality 35 n, Middle Cambrian, Fu-chóu series in limestone, Liau-tung, Manchuria. U. S. Nat. Mus., Cat. No. 57736.

Obolus obscurus Walcott (p. 66).

12. Interior of an imperfectly preserved dorsal valve, × 6. U. S. Nat. Mus., Cat. No. 52536*a*.

12*a*. Exterior of an exfoliated, partly restored dorsal valve, × 12. U. S. Nat. Mus., Cat. No. 52536*b*.

12*b*. Partly exfoliated and broken ventral valve showing concentric and radiating lines on the inner layers of the shell, × 4. U. S. Nat. Mus., Cat. No. 52535*a*.

12*c*. Enlargement of the concentric striæ of the exterior surface, × 8. U. S. Nat. Mus., Cat. No. 52535*b*.

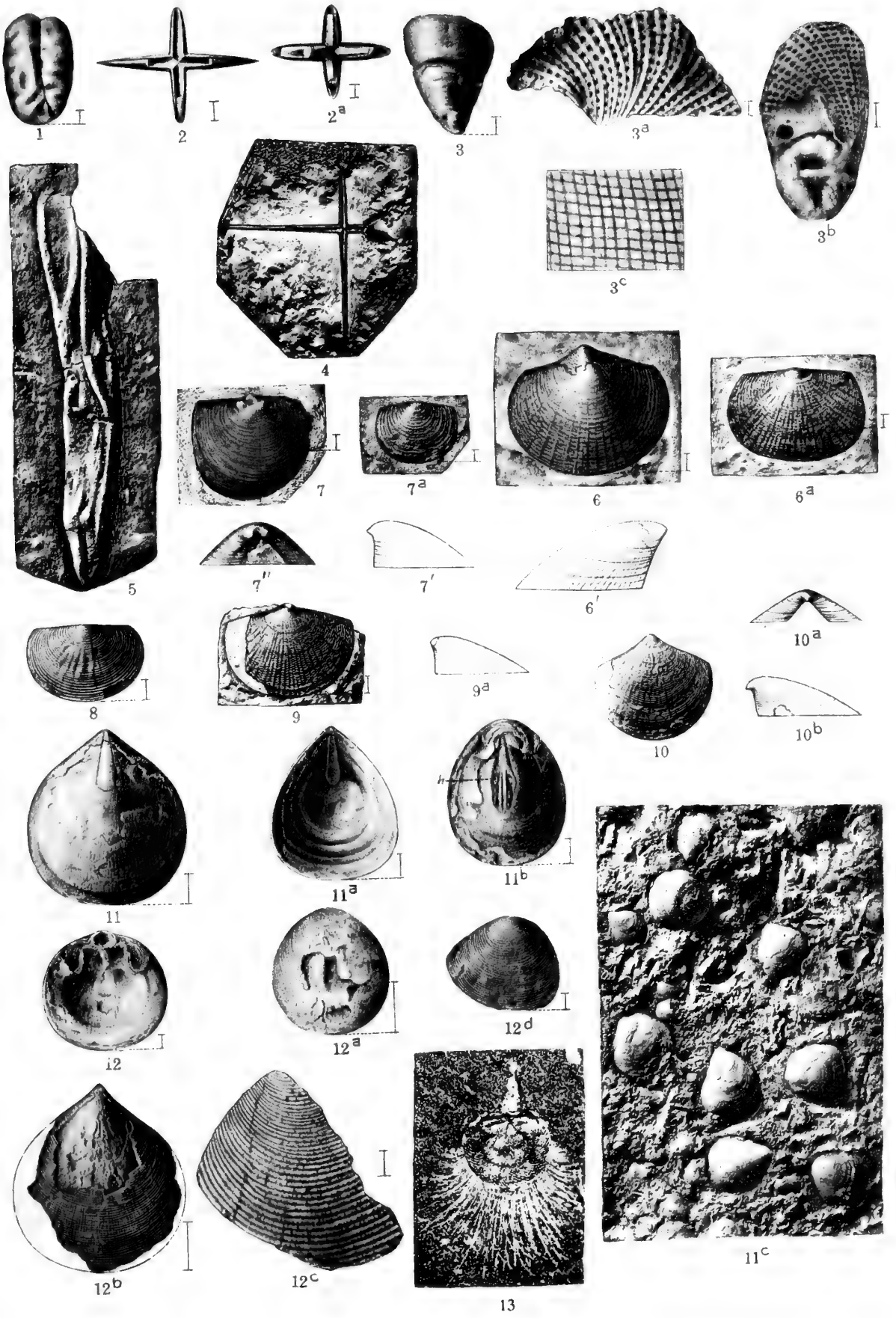
12*d*. Exterior surface of a broken dorsal valve, × 6. U. S. Nat. Mus., Cat. No. 52535*c*.

Figures 12 and 12*a* represent specimens from Locality C 63, Middle Cambrian, Kiu-lung group, southwest of Yen-chuang, Shan-tung; and 12*b–d*, specimens from Locality C 75, Middle Cambrian, Ki-chóu formation, south of Wu-t'ai-hién, Shan-si.

Micromitra (Iphidella) pannula White.

13. Ventral valve, × 3, showing setæ and pedicle, from Locality 35 k, Middle Cambrian, Burgess shale member of Stephen formation on mountain slope between Mount Field and Mount Wapta, north of Field, British Columbia, Canada. U. S. Nat. Mus., Cat. No. 59801.

This illustration is inserted in order to give a better conception of the shells illustrated by figs. 9 and 10.



COCKAYNE—BOSTON

Description of Plate 2.

Obolus damesi (Walcott) (p. 65).

1. Partly exfoliated ventral valve, showing main vascular sinuses and posterior portion of visceral area, × 6. U. S. Nat. Mus., Cat. No. 52529*a*.

1*a*. Surface of inner layers of the shell of a ventral valve × 6. U. S. Nat. Mus., Cat. No. 52529*b*.

1*b*. Partly exfoliated dorsal valve, × 6. U. S. Nat. Mus., Cat. No. 52529*c*.

1*c*. Partial cast of the interior of a dorsal valve, × 6. U. S. Nat. Mus., Cat. No. 52529*d*.

All of the specimens illustrated by figs. 1, 1*a–c* are from Locality C 10, Middle Cambrian, Kiu-lung group, southwest of Yen-chuang, Shan-tung.

1*d*. Enlargement to 2 diameters of a group of valves of this species lying on a parting of shaly limestone on which there are also numerous specimens of *Acrotreta shantungensis* Walcott. Locality 35r, Middle Cambrian, Fu-chóu series, Liau-tung, Manchuria. U. S. Nat. Mus., Cat. No. 57737.

1*e*. Flattened valves of this species, natural size, on argillaceous shale associated with *Acrothele matthewi eryx* Walcott. Locality 36d, Middle Cambrian, Fu-chóu series, Liau-tung, Manchuria. U. S. Nat. Mus., Cat. No. 57738.

Obolus matinalis (Hall) ? (p. 65).

2 (× 4) and 2*a* (× 6). Ventral and dorsal valves of partly exfoliated shells. Locality C 54, Upper Cambrian, Ch'au-mi-tién limestone west of Tsi-nan, Shan-tung. U. S. Nat. Mus., Cat. Nos. 52533*a* and 52533*b*.

Obolus minimus Walcott (p. 66).

3. A partly exfoliated ventral valve, showing the cast of the visceral area and the main vascular canals, × 8. Locality C 6, Middle Cambrian, Kiu-lung group limestone, south of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 52534*a*.

3*a*. Exterior of associated dorsal valve, × 6. U. S. Nat. Mus., Cat. No. 52534*b*.

Obolus shansiensis Walcott (p. 67).

4 and 4*a*. Partly exfoliated ventral valves, × 4. U. S. Nat. Mus., Cat. Nos. 52537*a* and 52538*a*.

4*b* and 4*c*. Partly exfoliated and broken dorsal valves, × 4. U. S. Nat. Mus., Cat. Nos. 52537*b* and 52538*b*.

The specimens represented by figs. 4 and 4*b* are from Locality C 32, Middle Cambrian, Ki-sin-ling limestone, south of Chön-p'ing-hién, Shan-si; and figs. 4*a* and 4*c*, Middle Cambrian, Ki-chóu limestone, south of Ting-hiang-hién, Shan-si.

4*d*. Exfoliated ventral valve, × 4, showing edges of lamellæ of the shell and radiating lines upon them. U. S. Nat. Mus., Cat. No. 57743.

4*e*. Enlargement to 3 diameters of a ventral and a dorsal valve in a limestone matrix. U. S. Nat. Mus., Cat. No. 57744.

4*f* and 4*g*. Enlargement to 3 diameters of two ventral valves as they occur in the limestone matrix. U. S. Nat. Mus., Cat. No. 57742.

The specimens represented by figs. 4*d–g* are from Locality 35r, Middle Cambrian, Fu-chóu series in limestone, Liau-tung, Manchuria.

Obolus (Westonia) blackwelderi Walcott (p. 68).

5 and 5*a*. Imperfect ventral valves. Locality C 6. U. S. Nat. Mus., Cat. Nos. 52540*a* and 52540*b*.

5*b*. Exterior of dorsal valve. Locality C 2, Middle Cambrian, Kiu-lung group, south of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 52541.

5*c*. Enlargement of the outer surface. U. S. Nat. Mus., Cat. No. 52540*c*.

Figures 5, 5*a*, and 5*c* represent specimens from Locality C 6, Middle Cambrian, Kiu-lung group, southwest of Yen-chuang, Shan-tung.

Lingulella marcia Walcott (p. 69).

6. Summit view and side profile of exfoliated ventral valve, showing vascular markings and cast of concentric lines of growth, × 10. U. S. Nat. Mus., Cat. No. 57562.

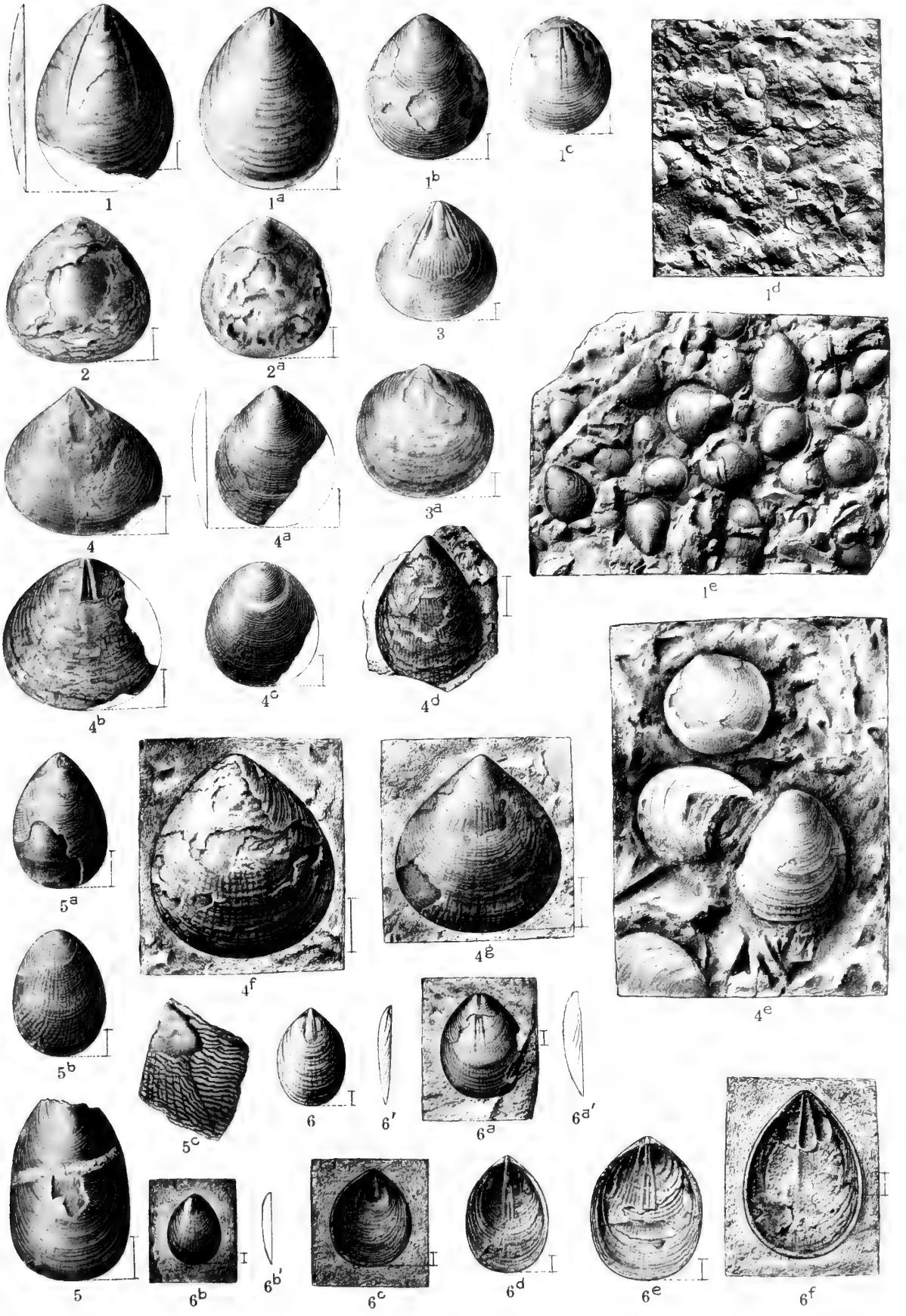
6*a*. View of a partly exfoliated dorsal valve, showing vascular markings, × 10. U. S. Nat. Mus., Cat. No. 57563.

6*b*. View of exterior surface and side profile of a dorsal valve, × 10. U. S. Nat. Mus., Cat. No. 57745.

6*c* and 6*d*. Interior of ventral valves, showing area and vascular markings, × 10. U. S. Nat. Mus., Cat. Nos. 57746 and 57747.

6*e* and 6*f*. Interior of dorsal valves showing vascular markings, × 10. U. S. Nat. Mus., Cat. Nos. 57748 and 57749.

The specimens represented by figures 6, 6*a–f* are from Locality 35q, Middle Cambrian, Fu-chóu series in compact shaly limestone about 120 feet (36.5 m.) above Locality 35p from which *Lingulella manchuriensis* comes, Province of Liau-tung, Manchuria.



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Description of Plate 3.

Lingulella manchuriensis Walcott (p. 69).

1. Summit view and side profile of a ventral valve, × 10. U. S. Nat. Mus., Cat. No. 57560.

1*a*. Summit view and side profile of a ventral valve, × 10. From Locality 35q, Middle Cambrian, Fu-chóu series, collected in a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria. U. S. Nat. Mus., Cat. No. 57750.

1*b*. Summit view and side profile of an exfoliated dorsal valve, × 10. U. S. Nat. Mus., Cat. No. 57561.

1*c*. Summit view and side profile of partly exfoliated broad form of dorsal valves. U. S. Nat. Mus., Cat. No. 57751.

1*d*. Summit view and side outline of a dorsal valve, exhibiting the outer surface of the shell, × 10. U. S. Nat. Mus., Cat. No. 57752.

1*e*. Enlargement to 4 diameters of a number of valves of this species, flattened in a fine arenaceous shale. U. S. Nat. Mus., Cat. No. 57753.

The specimens represented by figs. 1, 1*b–e* are from Locality 35p, Middle Cambrian, Fu-chóu series, calcareous and finely arenaceous shales, Province of Liau-tung, Manchuria.

Lingulella (Lingulepis) eros (Walcott) (p. 70).

2. Exterior of a broken ventral valve, × 8. From Locality C7, Middle Cambrian, Kiu-lung group, west of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 52527*a*.

2*a*. Exterior of an associated broken dorsal valve, × 8. U. S. Nat. Mus., Cat. No. 52527*b*.

Dicellomus parvus Walcott (p. 71).

3. Exterior of a ventral valve, × 10. U. S. Nat. Mus., Cat. No. 52523*c*.

3*a* and 3*b*. Interiors of dorsal valves, × 10. U. S. Nat. Mus., Cat. Nos. 52523*a* and 52523*b*.

3*c*. Exterior of a dorsal valve, × 10. U. S. Nat. Mus., Cat. No. 52523*d*.

3*d*. Exterior of a young shell, × 10. U. S. Nat. Mus., Cat. No. 52523*e*.

All of the specimens illustrated are from Locality C6, Middle Cambrian, Kiu-lung group, thin platy limestone, southwest of Yen-chuang, Shan-tung. The specimen represented by fig. 3*a* is on a piece of limestone with *Drepanura premesnili* Bergeron.

Obolella asiatica Walcott (p. 72).

4. Exterior of a ventral valve, × 4. From Locality C32, Lower Cambrian, drift bowlder, Southern Shan-si. U. S. Nat. Mus., Cat. No. 52525*a*.

4*a*. Exterior of an associated dorsal valve, × 4. U. S. Nat. Mus., Cat. No. 52525*b*.

Yorkia ? orientalis Walcott (p. 72).

5. Summit and side views of a ventral valve, × 8. U. S. Nat. Mus., Cat. No. 52521.

5*a*. Diagrammatic sketch of the minutely ornate exterior surface.

From Locality C71, Middle Cambrian, Ki-chóu formation, southwest of Tung-yü, Shan-si.

Acrothele matthewi eryx Walcott (p. 73).

6. Summit and side views of a partly exfoliated ventral valve, × 3. From Locality C4, Middle Cambrian. Kiu-lung group, limestone nodules southwest of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 52520.

6*a*. Summit view and side outline of a ventral valve, × 8. U. S. Nat. Mus., Cat. No. 57754.

6*b*. A large ventral valve compressed in fine arenaceous shale, × 2. U. S. Nat. Mus., Cat. No. 57755.

6*c*. A compressed and partly exfoliated ventral valve, showing faint radiating ridges, × 3. U. S. Nat. Mus., Cat. No. 57756.

6*d*. Enlargement to 6 diameters of the posterior portion of a ventral valve, showing apex and false area, × 6. U. S. Nat. Mus., Cat. No. 57757.

6*e*. View of a large dorsal valve, × 2. U. S. Nat. Mus., Cat. No. 57758.

6*f*. A large dorsal valve compressed in finely arenaceous shale, × 2. U. S. Nat. Mus., Cat. No. 57759.

6*g*. An exfoliated ventral valve, showing muscle scars and vascular markings, × 4. U. S. Nat. Mus., Cat. No. 57760.

6*h*. View of a small, partly exfoliated dorsal valve, showing cast of a portion of a median ridge and the pits adjoining it near the beak. U. S. Nat. Mus., Cat. No. 57761.

The specimens represented by figs. 6*a*, 6*c–e*, and 6*g–h* are from the limestones of Locality 35r, Middle Cambrian, Fu-chóu series, Province of Liau-tung, Manchuria.

The specimens represented by figs. 6*b* and 6*f* are from finely arenaceous buff-colored shale, Localities 36e and 36g, Middle Cambrian, Fu-chóu series, Province of Liau-tung, Manchuria.

Acrothele ? minuta Walcott (p. 74).

7. Exterior of a dorsal valve, × 15. From Locality C6, Middle Cambrian, Kiu-lung group, thin platy limestone, southwest of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 52519.

Acrothele rara Walcott (p. 74).

8. Interior of a ventral valve, × 6. From Locality C57, Middle Cambrian, Kiu-lung group, limestone nodules, north of Sin-t'ai-hién, Shan-tung. U. S. Nat. Mus., Cat. No. 52518*a*.

8*a*. Interior of an associated dorsal valve, × 6. U. S. Nat. Mus., Cat. No. 52518*b*.

Acrotreta lisani Walcott (p. 75).

9, 9*a*, and 9*b*. Summit, back, and side views of ventral valve, × 15. From Locality C22, Middle Cambrian, Ch'ang-hia limestone, at Ch'ang-hia, Shan-tung. U. S. Nat. Mus., Cat. No. 52505*a*.

9*c*. Exterior of an associated dorsal valve, × 15. U. S. Nat. Mus., Cat. No. 52505*b*.

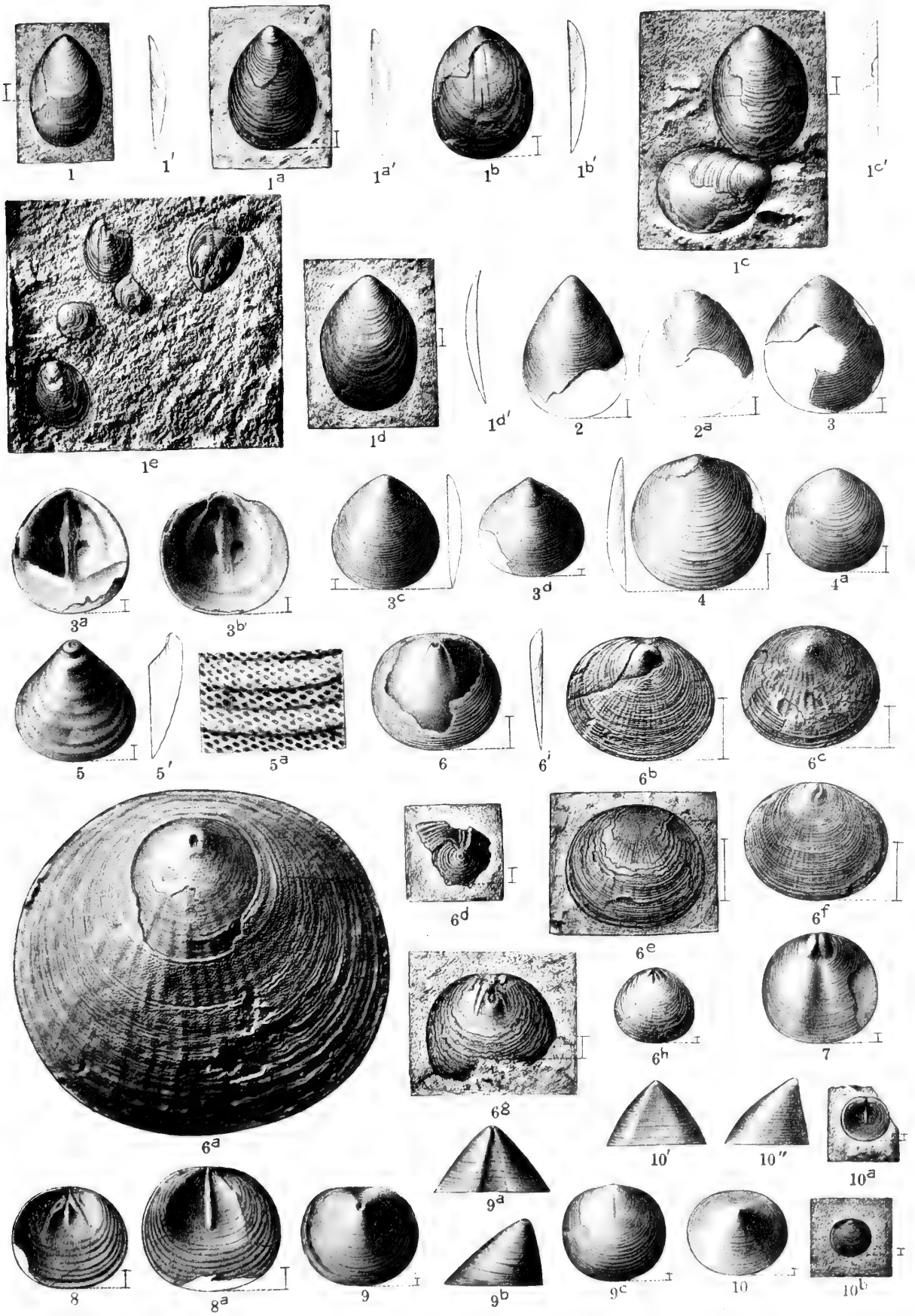
Acrotreta venia Walcott (p. 77).

10. Summit, side, and back views of a ventral valve, × 8. U. S. Nat. Mus., Cat. No. 57763.

10*a*. Interior of a dorsal valve showing median ridge and posterior muscle-scars. U. S. Nat. Mus., Cat. No. 57565.

10*b*. Exterior of very perfect dorsal valve, × 8. U. S. Nat. Mus., Cat. No. 57564.

The specimens represented by figs. 10, 10*a–b* are from the shaly limestones of Locality 35q, Middle Cambrian, Fu-chóu series in compact shaly limestone about 120 feet (36.5 m.) above Locality 35p from which *Lingulella manchuriensis* comes, Province of Liau-tung, Manchuria.



COCKAYNE— BOSTON

Description of Plate 4.

Acrotreta pacifica Walcott (p. 75).

1 and 1*a*. Summit and side views of ventral valve, × 15. From Locality C 5, Middle Cambrian, Kiu-lung group, southwest of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 52506*a*.

1*b*, 1*c*, and 1*d*. Summit, back, and side views of a small ventral valve, × 15. From same locality as fig. 1. U. S. Nat. Mus., Cat. No. 52506*b*.

1*e*. Partly exfoliated dorsal valve, × 15. From Locality C 2, Middle Cambrian, Kiu-lung group, south of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 52508.

1*f*. Summit view of a ventral valve crushed down in a fine arenaceous shale, × 8. Locality 35 p, Middle Cambrian, Fu-chóu series, Liau-tung, Manchuria. U. S. Nat. Mus., Cat. No. 57764.

Acrotreta shantungensis Walcott (p. 76).

2, 2*a*, and 2*b*. Summit, side, and back views of ventral valve, × 15. U. S. Nat. Mus., Cat. No. 52512*a*.

2*c*. Cast of interior of a ventral valve, showing cast of apical callosity, foraminal aperture, and base of main vascular sinuses, × 15. U. S. Nat. Mus., Cat. No. 52512*b*.

2*d*. Exterior of a dorsal valve, × 15. U. S. Nat. Mus., Cat. No. 52512*c*.

2*e*. Interior of a dorsal valve, × 15. U. S. Nat. Mus., Cat. No. 52512*d*.

The specimens illustrated are from Locality C 62, Middle Cambrian, Kiu-lung group, argillaceous limestone, south of Yen-chuang, Shan-tung.

Discinopsis sulcatus (Walcott) (p. 79).

3. Cast of interior of a ventral valve—the type specimen—× 8. From Locality C 56, Upper Cambrian, Ch'au-mi-tién limestone, west of Tsi-nan, Shan-tung. U. S. Nat. Mus., Cat. No. 52522.

Billingsella pumpellyi Walcott (p. 79).

4. Summit and side views (× 3) of a ventral valve of a specimen from C 61, Upper Cambrian, Kiu-lung group, southwest of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 52558*a*.

4*a*. Cast of interior of a ventral valve, showing tripartite divisions of the umbonal cavity, and the strong main vascular sinuses, × 3. U. S. Nat. Mus., Cat. No. 52557*a*.

4*b*. Partly exfoliated dorsal valve, × 3. U. S. Nat. Mus., Cat. No. 52557*b*.

4*c*. Enlargement of the radiating costæ toward the front margin of the shell. U. S. Nat. Mus., Cat. No. 52558*b*.

Figures 4*a–c* are of specimens from Locality C 36, Upper Cambrian, Ch'au-mi-tién limestone, at Ch'au-mi-tién, Shan-tung.

Billingsella richthofeni Walcott (p. 80).

5. Summit view and side outline of a ventral valve, × 4. From Locality C 3, Lower Cambrian, Man-t'o shale, southwest of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 52559.

Eoorthis agreste (Walcott) (p. 81).

6. Summit and side views of a ventral valve, × 2. U. S. Nat. Mus., Cat. No. 52545*a*.

6*a*. Enlargement of radiating costæ near front margin, × 3. U. S. Nat. Mus., Cat. No. 52545*b*.

From Locality C 28, Middle Cambrian, Ch'ang-hia limestone, east-southeast of Ch'ang-hia, Shan-tung.

Eoorthis doris (Walcott) (p. 81).

7. Summit and side views of a ventral valve, × 4. U. S. Nat. Mus., Cat. No. 52551*a*.

7*a*. Summit and side views of a dorsal valve which is nearly as convex as the ventral valve, × 4. U. S. Nat. Mus., Cat. No. 52551*b*.

From Locality C 64, Upper Cambrian, Kiu-lung group, southwest of Yen-chuang, Shan-tung.

Eoorthis kayseri (Walcott) (p. 82).

8. Slightly distorted ventral valve. Natural size. U. S. Nat. Mus., Cat. No. 52546*a*.

8*a*. Small, partly exfoliated dorsal valve, × 3. U. S. Nat. Mus., Cat. No. 52546*b*.

8*b*. Cast of interior of a dorsal valve, showing cast of strong median ridge and vascular sinuses, × 2. U. S. Nat. Mus., Cat. No. 52546*c*.

The three specimens illustrated are from Locality C 64, Upper Cambrian, Kiu-lung group, southwest of Yen-chuang, Shan-tung.

Eoorthis sp. undt. (*b*) (Walcott) (p. 85).

9. Exterior of a partly abraded ventral valve, × 3. From Locality C 71, Middle Cambrian, Ki-chóu limestone, southwest of Tung-yü, Shan-si. U. S. Nat. Mus., Cat. No. 52555.

Eoorthis kichouensis (Walcott) (p. 82).

10. Exterior of a ventral valve, and side outline, × 2. From Locality C 75, Middle Cambrian, Ki-chóu formation, south of Wu-t'ai-hién, Shan-si. U. S. Nat. Mus., Cat. No. 52550.

Eoorthis linnarssoni (Kayser) (p. 83).

11. Exterior of a partly exfoliated ventral valve, × 2.5. From Locality C 64, Upper Cambrian, Kiu-lung group, southwest of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 52549.

11*a*. Copy of portion of original figure from Kayser [1883, pl. III, fig. 1].

Eoorthis pagoda (Walcott) (p. 83).

12 and 12*a*. Exterior views of partly exfoliated ventral valves, × 2. U. S. Nat. Mus., Cat. Nos. 52552*a* and 52552*b*.

12*b*. Partly exfoliated dorsal valve, × 2. U. S. Nat. Mus., Cat. No. 52552*c*.

12*c*. Interior of a dorsal valve that has been slightly injured by abrasion, × 4. U. S. Nat. Mus., Cat. No. 52552*d*.

12*d*. Enlargement of the cast of a portion of the outer surface, × 6. U. S. Nat. Mus., Cat. No. 52552*e*.

All of the specimens illustrated are from Locality C 56, Upper Cambrian, Ch'au-mi-tién limestone, west of Tsi-nan, Shan-tung.

Eoorthis sp. undt. (*a*) (Walcott) (p. 84).

13. Summit and side views of a young shell at first referred doubtfully to *Orthis* (*Plectorthis*), × 8. From Locality C 26, Middle Cambrian, Ch'ang-hia limestone, north-northeast of Ch'ang-hia, Shan-tung. U. S. Nat. Mus., Cat. No. 52554.

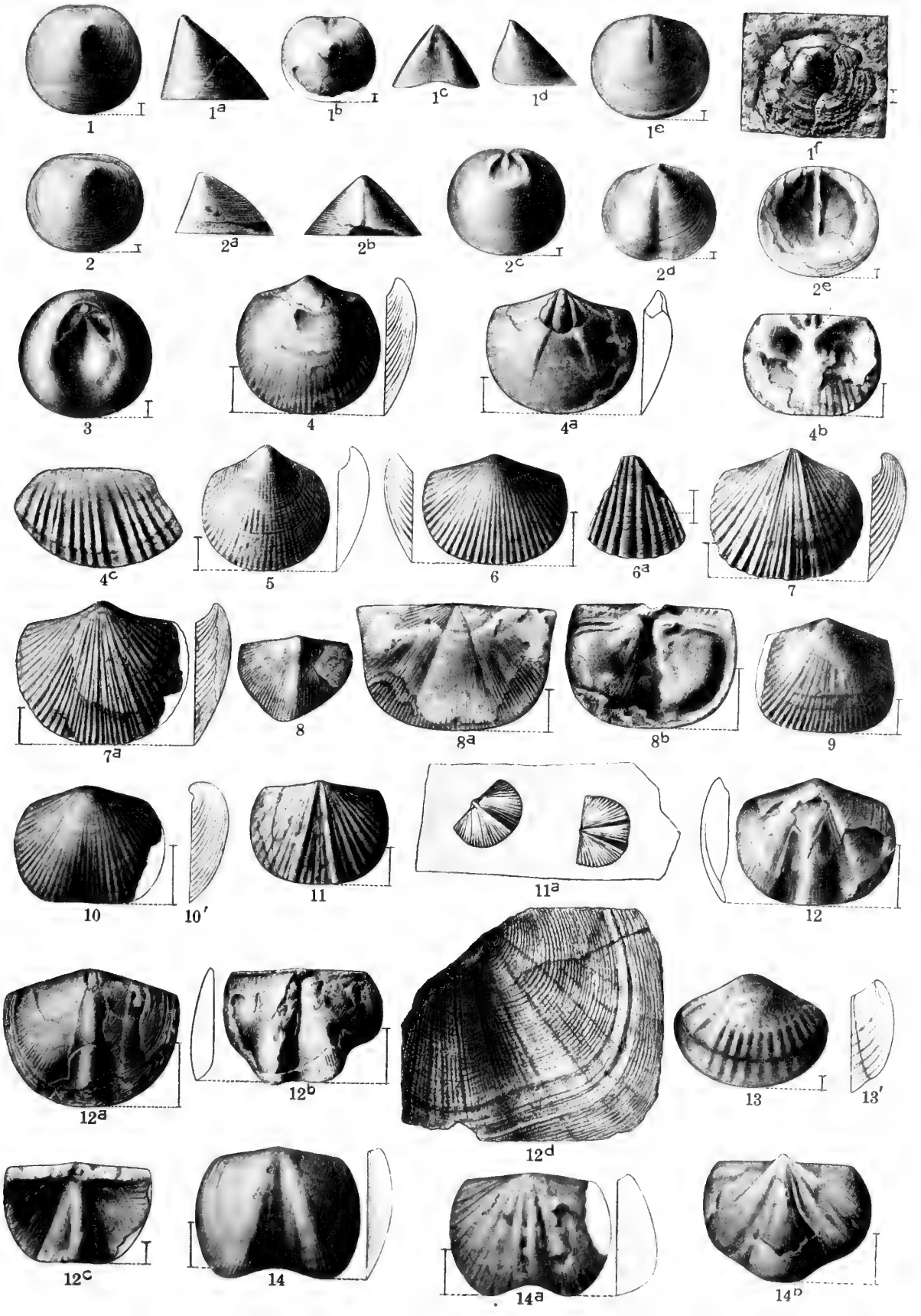
Huenella orientalis (Walcott) (p. 85).

14. Exterior of ventral valve, with side outline, × 2.5. U. S. Nat. Mus., Cat. No. 52564*a*.

14*a*. Partly exfoliated dorsal valve, with side outline, × 2.5. U. S. Nat. Mus., Cat. No. 52564*b*.

14*b*. Smooth form of a dorsal valve, preserving a portion of the outer surface of the shell, × 3. U. S. Nat. Mus., Cat. No. 52564*c*.

From Locality C 64, Upper Cambrian, Kiu-lung group, southwest of Yen-chuang, Shan-tung.



COCHAYNE—BOSTON

Description of Plate 5.

Syntrophia orthia Walcott (p. 85).

1. Exterior view of a ventral valve, × 3, from Locality C 56, Upper Cambrian, Ch'au-mi-tién limestone, Pagoda Hill, Tsi-nan, Shan-tung. U. S. Nat. Mus., Cat. No. 52562.

1*a*. Exterior view of a ventral valve with a narrower median sulcus than the specimen represented by fig. 1, × 3. Specimen from Locality C 64, Upper Cambrian, Kiu-lung group, 2.7 miles (4.3 km.) southwest of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 52563.

1*b*. Exterior view and side outline of a dorsal valve, × 3, from Locality C 54, Upper Cambrian, Ch'au-mi-tién limestone, two-thirds of a mile (1.1 km.) west of Tsi-nan, Shan-tung. U. S. Nat. Mus., Cat. No. 52561.

Scenella ? dilatatus Walcott (p. 87).

2. Fragmentary specimen, showing what is supposed to be the outer surface of the campanulate border, × 3. U. S. Nat. Mus., Cat. No. 57767.

2*a*. Interior surface of the campanulate border, showing the base of the elevated central portion, × 3. U. S. Nat. Mus., Cat. No. 57768.

From Locality C 70, Middle Cambrian, Ki-chóu limestone, south-southeast of Tung-yü, Shan-si.

Scenella clotho Walcott (p. 86).

3 and 3*a*. Summit view of a specimen from which the apex has been broken, with its matrix (3*a*), × 6. From Locality C 18, Middle Cambrian, Ch'ang-hia limestone, east of Ch'ang-hia, Shan-tung. U. S. Nat. Mus., Cat. No. 57769.

Scenella sp. undt. Walcott (p. 87).

4. Summit view of the only specimen in the collection. From Locality C 56, Upper Cambrian, Ch'au-mi-tién limestone, Pagoda Hill, Tsi-nan, Shan-tung. U. S. Nat. Mus., Cat. No. 57770.

Matherella circe (Walcott) (p. 88).

5. View of the outer whorl of the spire of the type specimen, with a side outline, × 6. From Locality C 56, Upper Cambrian, Ch'au-mi-tién limestone, Pagoda Hill, Tsi-nan, Shan-tung. U. S. Nat. Mus., Cat. No. 57771.

Straparollina sp. undt. Walcott (p. 88).

6. View of the lower side of the outer whorl of the only specimen in the collection, × 2. From Locality C 55, Middle Cambrian, Kiu-lung group, south of Tsi-nan, Shan-tung. U. S. Nat. Mus., Cat. No. 57772.

Helcionella ? clurius (Walcott) (p. 90).

7. Dorsal and side views of the type specimen described in the text. Natural size. From Locality C 46, Middle Cambrian, Ch'ang-hia limestone at Ch'au-mi-tien, Shan-tung. U. S. Nat. Mus., Cat. No. 57773.

Helcionella rugosa chinensis (Walcott) (p. 91).

8. Side view of the type specimen, showing the septum toward the apex, × 2. From Locality C 3, Lower Cambrian, Man-t'o shale, southwest of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 57774.

Pelagiella chronus (Walcott) (p. 88).

9 (C 4) and 9*a* (C 1). View of dorsal side of two specimens, showing slight variation in the position of the sharp ridge, × 10. U. S. Nat. Mus., Cat. Nos. 57778 and 57779.

9*b*. Side outline of another specimen, × 10. U. S. Nat. Mus., Cat. No. 57780.

From Localities C 4 and C 1, Middle Cambrian, Kiu-lung group, in limestone south and southwest of Yen-chuang, Shan-tung.

Pelagiella pagoda (Walcott) (p. 89).

10. View of inner side of a specimen preserving the exterior shell, × 10. U. S. Nat. Mus., Cat. No. 57782.

10*a*. View of inner side of the cast of a large specimen, × 4. U. S. Nat. Mus., Cat. No. 57783.

From Locality C 56, Upper Cambrian, Ch'au-mi-tién limestone, Pagoda Hill, Tsi-nan, Shan-tung.

Helcionella ? ? simplex (Walcott) (p. 92).

11. Summit and side view of the type specimen, × 10. From Locality C 70, Middle Cambrian, Ki-chóu limestone, south-southwest of Tung-yü, Shan-si. U. S. Nat. Mus., Cat. No. 57777.

Pelagiella willisi (Walcott) (p. 90).

12. View of outer side of a specimen preserving the outer and inner whorls, × 10. U. S. Nat. Mus., Cat. No. 57784.

13. View of the inner side of a specimen showing a slight depression within the dorsal angle, × 10. U. S. Nat. Mus., Cat. No. 57785.

From Locality C 72, Middle Cambrian, Ki-chóu formation, east of Fang-lan-chön, Shan-si.

Description of Plate 5—Continued.

Pelagiella clytia (Walcott) (p. 89).

14. View of the outer whorl of the type specimen of the species, × 10. U. S. Nat. Mus., Cat. No. 57786.

From Locality C47, Upper Cambrian, Ch'au-mi-tién limestone at Ch'au-mi-tién, Shan-si.

Helcionella rugosa orientalis (Walcott) (p. 91).

15. Side view of a rather strongly curved specimen, × 10. From Locality C18, Middle Cambrian, Ch'ang-hia limestone, east of Ch'ang-hia, Shan-tung. U. S. Nat. Mus., Cat. No. 57775.

15*a*. Side view of a slender, banded specimen, × 10. From Locality C21, Middle Cambrian, Ch'ang-hia formation at Ch'ang-hia, Shan-tung. U. S. Nat. Mus., Cat. No. 57776.

Hyolithes cybele Walcott [see plate 6, fig. 7] (p. 92).

16 (× 3) and 16*b* (× 2). Ventral and dorsal views of typical specimens of the species from Locality C2, Middle Cambrian, Kiu-lung group, south of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. Nos. 57787 and 57788.

16*a*. Ventral view of a specimen (× 4) from Locality C22, Middle Cambrian, Ch'ang-hia limestone, Ch'ang-hia, Shan-tung. U. S. Nat. Mus., Cat. No. 57789.

16*c*. Exterior and end views of operculum associated with this species in Liau-tung, × 4. From Locality 35n, Middle Cambrian, Fu-chóu series, Manchuria. U. S. Nat. Mus., Cat. No. 57790.

Hyolithes daphnis Walcott (p. 93).

17. Dorsal view of the type specimen, with outline of cross-section. Natural size. From Locality C64, Upper Cambrian, Kiu-lung group, 2.7 miles (4.3 km.) southwest of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 57797.

Hyolithes delia Walcott (p. 94).

18. Dorsal view of the type specimen of the species, × 6. From Locality C3, Lower Cambrian, Man-t'o shales, southwest of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 57798.

Hyolithes sp. undt. Walcott (p. 94).

19. Fragment of a species of *Hyolithes*, with a subtriangular aperture, associated with *Orthotheca doris*, × 6. From Locality C32, Lower Cambrian, drift bowlder, Southern Shan-si. U. S. Nat. Mus., Cat. No. 57796.

Hyolithes sp. undt. Walcott (Operculum) (p. 94).

20. Operculum associated with *Hyolithes cybele*, × 6. From Locality C4, Middle Cambrian, Kiu-lung group, limestone in shale, southwest of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 57795.

Orthotheca cyrene Walcott (p. 94).

21. Ventral view and transverse section of a typical form of this species, × 4. U. S. Nat. Mus., Cat. No. 57799.

21*a*. Dorsal view of a specimen showing the broad groove on the dorsal face, × 4. U. S. Nat. Mus., Cat. No. 57800.

Figures 21 and 21*a* are drawn from specimens found at Locality C47, Upper Cambrian, Ch'au-mi-tién limestone, Ch'au-mi-tién, Shan-tung.

Orthotheca cyrene dryas Walcott (p. 95).

22, 22[1], and 22*c*. Dorsal and side views and outline of section, × 7. U. S. Nat. Mus., Cat. No. 57803.

22*a*. Dorsal view, × 5. U. S. Nat. Mus., Cat. No. 57804.

22*b*. Dorsal view (× 3) of specimen. U. S. Nat. Mus., Cat. No. 57805.

All of the specimens illustrated are from Locality C2, Middle Cambrian, Kiu-lung group, 2 miles (3.2 km.) south of Yen-chuang, Shan-tung.

Orthotheca glabra Walcott [see plate 6, fig. 7] (p. 97).

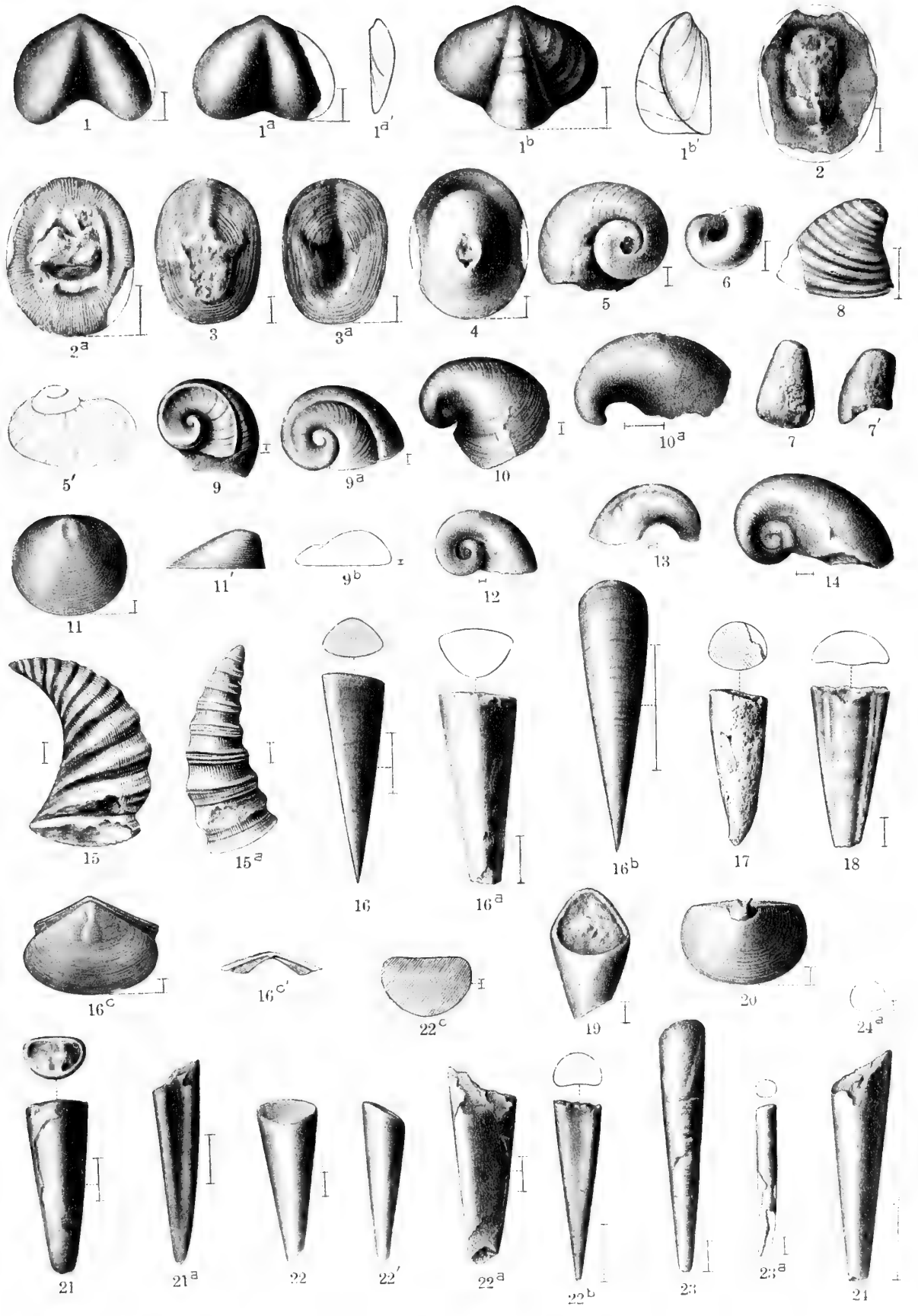
23. A partly exfoliated specimen (× 8) from Locality C71, Middle Cambrian, Ki-chóu formation from 4 miles (6.4 km.) south-southwest of Tung-yü, Shan-si. U. S. Nat. Mus., Cat. No. 57566.

23*a*. A minute, slender, broken specimen (× 8) from Locality C72, Middle Cambrian, Ki-chóu formation 4 miles (6.4 km.) east of Fang-lan-chön, Shan-si. U. S. Nat. Mus., Cat. No. 57567.

Orthotheca daulis Walcott (p. 95).

24. Ventral view of the type specimen, × 2.5. From Locality C23, Middle Cambrian, Ch'ang-hia formation, east-southeast of Ch'ang-hia, Shan-tung. U. S. Nat. Mus., Cat. No. 57809.

24*a*. Transverse section of specimen associated with the specimen represented in fig. 24. U. S. Nat. Mus., Cat. No. 57810.


1
1a
1a'
1b
1b'
2
2a
3
3a
4
5
6
8
5'
9
9a
10
10a
7
7'
11
11'
9b
12
13
14
15
15a
16
16a
16b
17
18
16c
16c'
22c
19
20
24a
21
21a
22
22'
22a
22b
23
23a
24

Description of Plate 6.

Orthotheca delphus Walcott [see figs. 5, 6] (p. 96).

1. View looking down on rounded angle formed by union of dorsal and ventral faces, × 4. From Locality C 4, Middle Cambrian, Kiu-lung group, southwest of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 57811.

1*a*. Transverse section of specimen, associated with specimen represented by fig. 1*b*. U. S. Nat. Mus., Cat. No. 57812*a*.

1*b*. Ventral side of a specimen that tapers more rapidly than the specimen represented by fig. 1, × 8. From Locality C 57, Middle Cambrian, Kiu-lung group, north of Sin-t'ai-hien, Shan-tung. U. S. Nat. Mus., Cat. No. 57812*b*.

Orthotheca doris Walcott (p. 97).

2. Side view and outline of transverse section of type specimen, × 4. From Locality C 32, Middle Cambrian, Ki-sin-ling limestone, south of Chön-p'ing-hien, Southern Shan-si. U. S. Nat. Mus., Cat. No. 57813.

Orthotheca sp. undt. Walcott (p. 98).

3. Dorsal view and outline of transverse section of fragment, × 8. From Locality C 56, Upper Cambrian, Ch'au-mi-tién limestone, west of Tsi-nan, Shan-tung. U. S. Nat. Mus., Cat. No. 57814.

Cyrtoceras cambria Walcott (p. 98).

4. Side view of specimen preserving chamber of habitation and eight septa, × 4. U. S. Nat. Mus., Cat. No. 57819.

4*a*. Side view of fragment of chambered portion of shell, × 6. U. S. Nat. Mus., Cat. No. 57820.

4*b*. End view of specimen shown by fig. 4*a*, showing form of transverse section and position and size of siphuncle, × 6.

4*c*. Side view of fragment of chambered portion of shell, showing curvature of septa, × 6. U. S. Nat. Mus., Cat. No. 57821.

All of the specimens illustrated are from Locality C 56, Upper Cambrian, Ch'au-mi-tién limestone, west of Tsi-nan, Shan-tung.

Orthotheca delphus Walcott [see figs. 1, 1*a–b*] (p. 96).

5. Photograph (× 4) of a fragment of limestone containing specimens of this species. From Locality 35 r, Middle Cambrian, Fu-chóu series, Liau-tung, Manchuria. U. S. Nat. Mus., Cat. No. 57815.

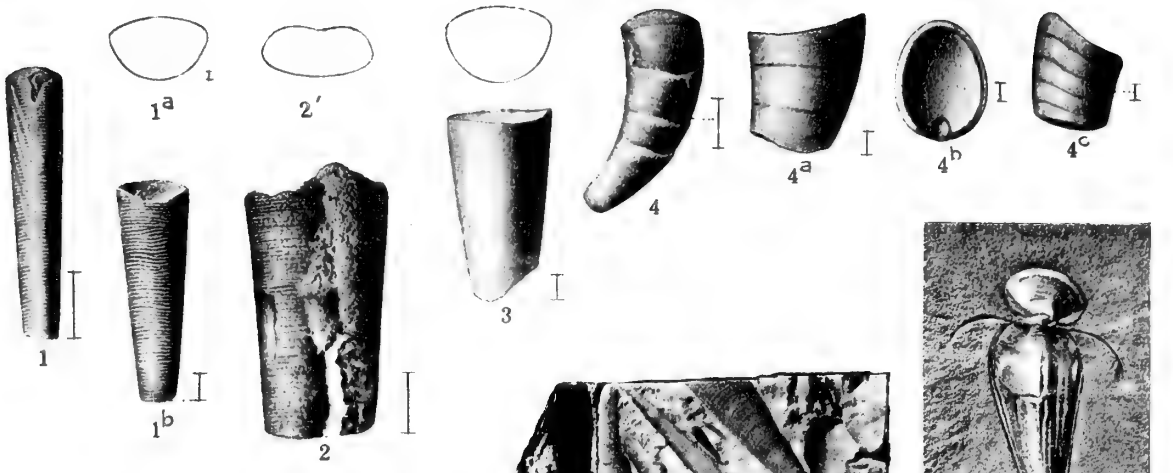
6. Photograph (× 4) of type specimen of species. From Locality C 4, Middle Cambrian, Kiu-lung group, southwest of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 57816.

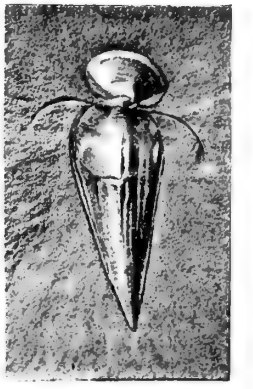
Orthotheca glabra Walcott [see plate 5, figs. 23, 23*a*] (p. 97) and Hyolithes cybele Walcott [see plate 5, figs. 16, 16*a–c*] (p. 92).

7. Photograph (× 4) of fragment of limestone containing specimens of the two species *O. glabra* and *H. cybele*, and brachiopods *Obolus*, *Acrothele*, and *Acrotreta*. From Locality 35 n, Middle Cambrian, Fu-chóu series, Liau-tung, Manchuria. U. S. Nat. Mus., Cat. Nos. 57807 and 57808.

Hyolithes carinatus Matthew.

8. Ventral view of a specimen (× 2) with the operculum and the fin or arm supports. From Locality 35 k, Middle Cambrian, Burgess shale member of Stephen formation on mountain slope between Mount Field and Mount Wapta, north of Field, British Columbia, Canada. U. S. Nat. Mus., Cat. No. 57625.





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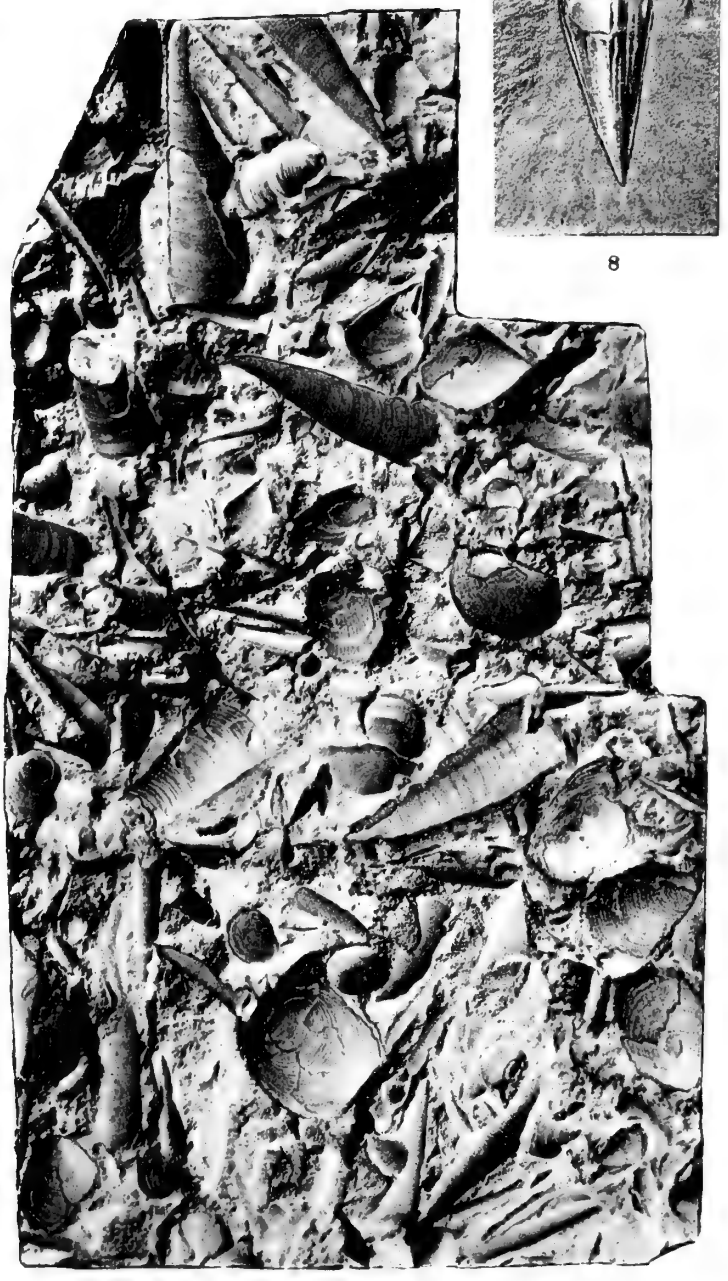

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6

COCKAYNE—BOSTON

Description of Plate 7.

Agnostus parvifrons latelimbatus Lorenz (p. 102).

1. Cephalon, × 5. [After Lorenz, 1906, plate v, fig. 10.]
1*a*. Pygidium, × 5. Reproduced from a photograph of the specimen illustrated by Lorenz. Now in collection of University Museum at Freiburg, Germany. [Lorenz, 1906, plate iv, fig. 9*a*.]
2. A cephalon, × 4, that occurs on the slab of limestone illustrated on plate 11. This may possibly belong to this species. From Locality C 6, Middle Cambrian, Kiu-lung group, southwest of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 57847.

Agnostus douvilléi Bergeron [see plate 11, figs. 6, 7] (p. 100).

3 and 3*a*. Pygidia, × 4, as they occur on a slab of limestone. From Locality C 6, Middle Cambrian, Kiu-lung group, southwest of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 57845*a*.
3*b*. Associated cephalon, × 4. (C 6.) U. S. Nat. Mus., Cat. No. 57845*b*.
8 and 8*a*. Cephalon and pygidium. [After Monke, 1903, plate iii, figs. 1 and 4.]

Agnostus chinensis Dames (p. 99).

4 and 4*a*. Cephala and pygidia compressed in argillaceous shale, × 4. From Locality 36*g*, Middle Cambrian, Fu-chóu series, Liau-tung, Manchuria. U. S. Nat. Mus., Cat. No. 57822.
4*b*. An associated entire dorsal shield, × 4. U. S. Nat. Mus., Cat. No. 57823.
5 and 5*a*. Cephalon and pygidium of a typical form of the species, × 4. U. S. Nat. Mus., Cat. Nos. 57824 and 57825.
5*b*. Thoracic segment, × 7. U. S. Nat. Mus., Cat. No. 57826.
5*c*. Cephalon differing slightly in detail from that represented by fig. 5. U. S. Nat. Mus., Cat. No. 57827.

The specimens represented by figs. 5, 5*a–c* are from Locality C 1, Middle Cambrian, Kiu-lung group, south of Yen-chuang, Shan-tung.

6 and 6*a*. Cephalon and pygidium. [After Dames, 1883, plate ii, figs. 18*a* and 19*a*.]

Agnostus kushanensis Walcott (p. 101).

7. Typical form of cephalon, × 4. U. S. Nat. Mus., Cat. No. 57840.
7*a*. Segment of thorax, × 4. U. S. Nat. Mus., Cat. No. 57841.
7*b*. Typical form of pygidium, × 4. U. S. Nat. Mus., Cat. No. 57842.

From Locality C 57, Middle Cambrian, Kiu-lung group limestone nodules, north of Sin-t'ai-hién, Shan-tung.

Shumardia sp. undt. Walcott.

9. A pygidium referred to this genus, × 6. From Locality C 51, Middle Cambrian, Ch'ang-hia limestone at Ch'au-mi-tién, Shan-tung. U. S. Nat. Mus., Cat. No. 57843.

Microdiscus orientalis Walcott (p. 102).

10. View of interior of cephalon of type specimen, × 7. From Locality C 32, Middle Cambrian, Ki-sin-ling limestone, river drift, Southern Shan-si. U. S. Nat. Mus., Cat. No. 57844.

Redlichia chinensis Walcott [see plate 24, figs. 1, 1*a*] (p. 104).

11. Central parts of cephalon, exclusive of postero-lateral limbs; and side outline of same. Natural size. From Locality C 16, Lower Cambrian, Man-t'o shale, south of Ch'ang-hia, Shan-tung. U. S. Nat. Mus., Cat. No. 57848.
11*a*. Free cheek associated with cephalon represented by fig. 11. Natural size. U. S. Nat. Mus., Cat. No. 57849.
11*b*. Fragment of a thoracic segment. Natural size. From Locality C 27 [same as C 16], Lower Cambrian, Man-t'o shale (fig. 11) at Ch'ang-hia, Shan-tung. U. S. Nat. Mus., Cat. No. 57850.
11*c*. Weathered specimen showing 7 thoracic segments. Natural size. From Locality C 15 [same as C 27, fig. 11*b*], Lower Cambrian, Man-t'o shale at Ch'ang-hia, Shan-tung. U. S. Nat. Mus., Cat. No. 57851.
11*d*. Fragment of thoracic segment, with strong median spine. Natural size. From Locality C 16 [same as fig. 11], Lower Cambrian, Man-t'o shale, south of Ch'ang-hia, Shan-tung. U. S. Nat. Mus., Cat. No. 57852.

Redlichia nobilis Walcott (p. 105).

12. Broken specimen of cranidium restored in outline from other specimens; and side outline, × 1.5. U. S. Nat. Mus., Cat. No. 57853.
12*a*. Free cheek associated. U. S. Nat. Mus., Cat. No. 57854.
12*b*. A cranidium with frontal border outlined from an associated specimen, × 1.5. U. S. Nat. Mus., Cat. No. 57855.
12*c*. Associated minute cranidium, × 10, tentatively referred to this species. U. S. Nat. Mus., Cat. No. 57856.
12*d*. Associated hypostoma, × 3. U. S. Nat. Mus., Cat. No. 57857.
12*e*. Associated thoracic segment, × 2. U. S. Nat. Mus., Cat. No. 57858.

All of the specimens illustrated by figs. 12, 12*a–e* are from Locality C 3, Lower Cambrian, Man-t'o shale, southwest of Yen-chuang, Shan-tung.

Description of Plate 7—Continued.

Redlichia ? finalis Walcott (p. 105).

13. Central parts of a cranidium with strong occipital spine, and side outline, × 6. U. S. Nat. Mus., Cat. No. 57859.

13*a*. Associated free cheek, × 4. U. S. Nat. Mus., Cat. No. 57860.

13*b*. Associated fragment of what may be a median thoracic spine, × 2. U. S. Nat. Mus., Cat. No. 57861.

The three specimens illustrated occur at Locality C 58, Middle Cambrian, Ch'ang-hia limestone, southeast of Kao-kia-p'u, Shan-tung.

Redlichia ? sp. undt. (*a*) **Walcott** (p. 105).

14. Fragment of a free cheek, showing genal angle and spine. Natural size. From Locality C 6, Middle Cambrian, Kiu-lung group, southwest of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 57862.

Redlichia sp. undt. (*b*) **Walcott** (p. 106).

15. Fragment of free cheek with a genal spine; also with a long sharp spine directed obliquely inward and backward, apparently at posterior margin of eye-lobe, × 2. From Locality C 16, Lower Cambrian, Man-t'o shale, south of Ch'ang-hia, Shan-tung. U. S. Nat. Mus., Cat. No. 57863.

Redlichia sp. undt. (*c*) **Walcott** (p. 106).

16. Free cheek from same stratigraphic horizon as free cheeks represented by figs. 12*a* and 15, Natural size. From Locality C 27, Lower Cambrian, Man-t'o shale at Ch'ang-hia, Shan-tung. U. S. Nat. Mus., Cat. No. 57864.

16*a*. Associated fragment of thoracic segment. Natural size. U. S. Nat. Mus., Cat. No. 57865.

Stephanocare richthofeni Monke (p. 114).

17. A cranidium. [After Monke, 1903, plate VII, fig. 3.]

17*a*. A cranidium showing a slightly different posterior margin as compared with fig. 17, × 4. U. S. Nat. Mus., Cat. No. 57866.

17*b*. Free cheek associated with fig. 17*a*, × 4. U. S. Nat. Mus., Cat. No. 57867.

17*c*. Pygidium with unusually long spine on the border. U. S. Nat. Mus., Cat. No. 57868.

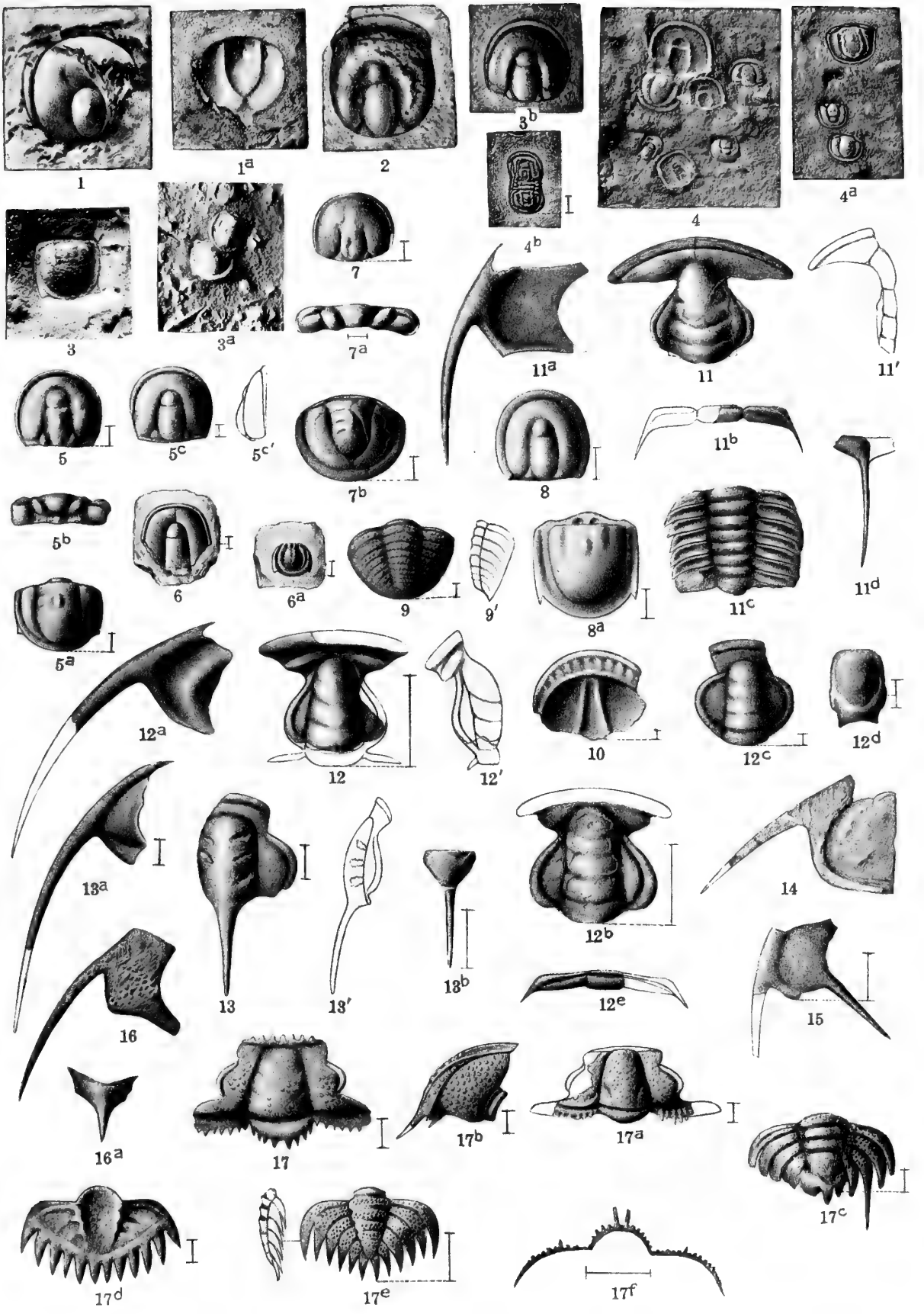
17*d*. Under side of pygidium, × 4. U. S. Nat. Mus., Cat. No. 57869.

The specimens represented by figs. 17*c* and 17*d* are from Locality C 55, Middle Cambrian, Kiu-lung group, southeast of Tsi-nan, Shan-tung.

17*e*. Typical form of pygidium and side outline, × 2. U. S. Nat. Mus., Cat. No. 57870.

17*f*. Profile view of a thoracic segment, × 3. U. S. Nat. Mus., Cat. No. 57871.

All of the specimens illustrated are from Locality C 6, except those represented by figs. 17*c* and 17*d*, Middle Cambrian, Kiu-lung group, southwest of Yen-chuang, Shan-tung.



COCKAYNE—BOSTON

Description of Plate 8.

Dorypyge richthofeni Dames (p. 108).

1. Cranidium with finely granulated surface (× 1.5), and side outline. From Locality C 1, Middle Cambrian, Kiu-lung group, south of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 57876.

1*a*. Central parts of a cephalon, showing glabellar furrows and coarse granulations, × 1.5. From Locality C 19, Middle Cambrian, Ch'ang-hia limestone at Ch'ang-hia, Shan-tung. U. S. Nat. Mus., Cat. No. 57878.

1*b*. Cranidium, showing postero-lateral limb, base of occipital spine, and glabella like that of fig. 1, with which it is associated in the limestone. (C 1.) U. S. Nat. Mus., Cat. No. 57877.

1*c*. Top and side views of pygidium associated with 1*a*, × 1.5. (C 19.) U. S. Nat. Mus., Cat. No. 57879.

1*d*. Thoracic segment, showing straight pleural groove, × 2. From Locality C 29, Middle Cambrian, Ch'ang-hia limestone, west of Ch'ang-hia, Shan-tung. U. S. Nat. Mus., Cat. No. 57881.

1*e*. Fragmentary pygidium with very cylindrical axis. Natural size. From Locality C 57, Middle Cambrian, Kiu-lung group, north of Sin-t'ai-hién, Shan-tung. U. S. Nat. Mus., Cat. No. 57882.

1*f*. Hypostoma associated with 1*a*, × 1.5. (C 19.) U. S. Nat. Mus., Cat. No. 57880.

Dorypyge richthofeni lævis Walcott (p. 109).

2. Top view and side outline of central parts of cephalon, × 1.5. From Locality C 72, Middle Cambrian, Ki-chóu formation, east of Fang-lan-chön, Shan-si. U. S. Nat. Mus., Cat. No. 57883.

2*a*. Free cheek associated with the cranidium represented by fig. 2, × 2. U. S. Nat. Mus., Cat. No. 57884.

2*b*. Hypostoma, × 2. From Locality C 71 (same horizon as fig. 2), Middle Cambrian, Ki-chóu formation, southwest of Tung-yü, Shan-si. U. S. Nat. Mus., Cat. No. 57885.

Dorypyge bispinosa Walcott (p. 107).

3. Enlarged view of the type specimen; and side outline, × 1.5. From Locality C 2, Middle Cambrian, Kiu-lung group, south of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 57886.

Stephanocare ? sinensis (Bergeron) (p. 116).

4. Partly exfoliated pygidium, × 3. From Locality C 6, Middle Cambrian, Kiu-lung group, southwest of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 57872.

This specimen is on a slab of limestone with specimens of *Blackwelderia sinensis*. [See plate 9, fig. 5*a*.]

4*a*. View (× 4) of under side of pygidium, showing doublure and the irregular spines of the border, from same locality (C 6) as specimen represented by fig. 4. U. S. Nat. Mus., Cat. No. 57873.

Stephanocare ? monkei Walcott (p. 113).

5. Pygidium doubtfully referred to this genus (× 2). It is associated with *Stephanocare ? sinensis* and *S.* sp. undt., fig. 6. From Locality C 6, Middle Cambrian, Kiu-lung group, southwest of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 57601.

Stephanocare sp. undt. Walcott (p. 116).

6. A minute pygidium, × 4, tentatively referred to this genus, associated with *Stephanocare ? monkei*, fig. 5. U. S. Nat. Mus., Cat. No. 57875.

Olenoides nevadensis (Meek).

7. Two segments of thorax of type specimen that show the broad, straight pleural groove. Note the broad node at the inner end of the groove next to the axis that narrows the groove and bends it forward. From Locality 3 S, Middle Cambrian, Wheeler formation, Antelope Springs, House Range, Utah. U. S. Nat. Mus., Cat. No. 15453.

Olenoides curticei Walcott [see Walcott, 1886, plate xxv. fig. 7].

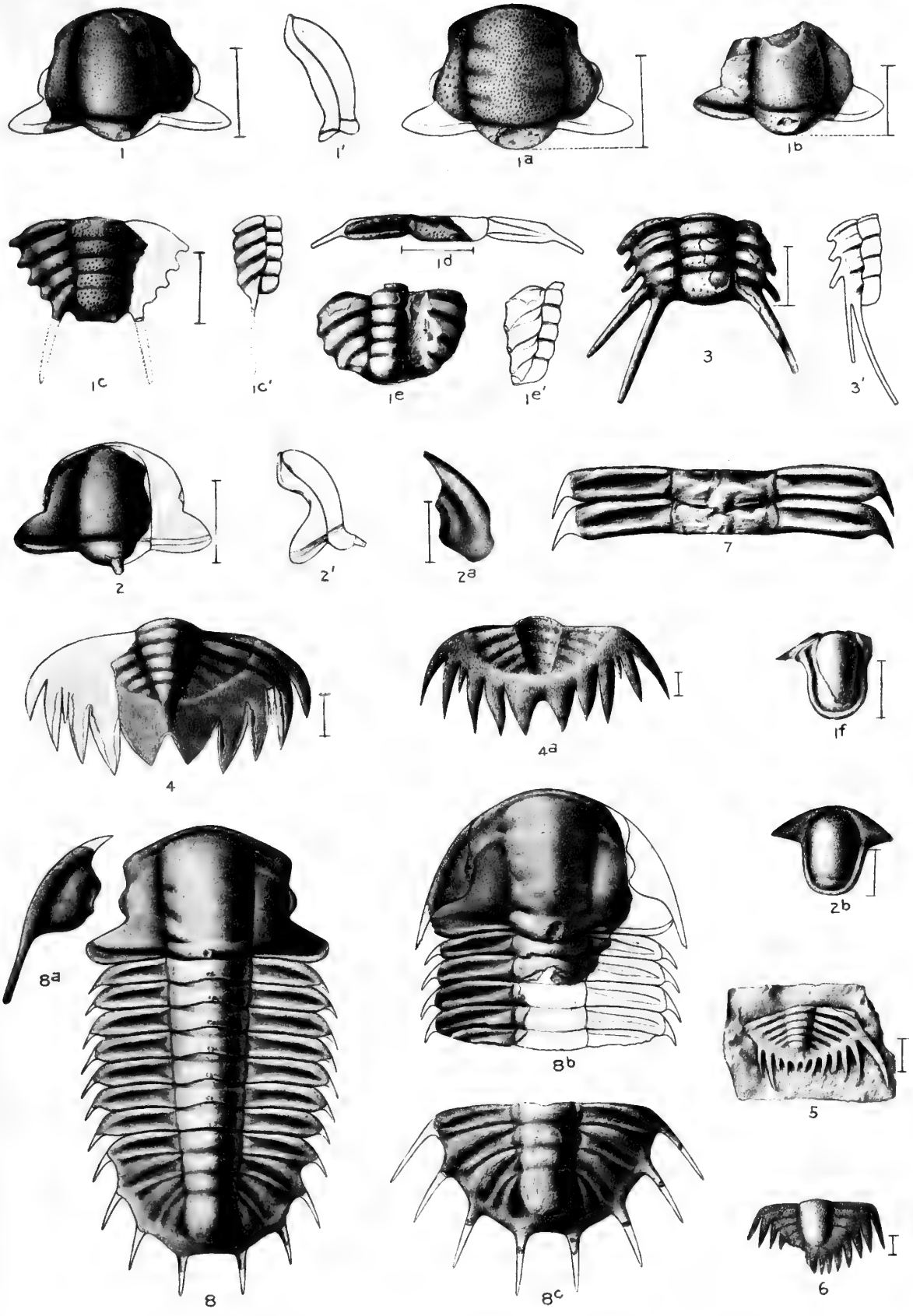
8. Outlines from nearly an entire specimen that has central portions of segments of thorax filled in from another specimen. Note pleural grooves on segment and compare with fig. 7. Natural size. From Locality 90 x, Middle Cambrian, Conasauga shale, at Cedar Bluff, Cherokee County, Alabama. U. S. Nat. Mus., Cat. No. 58534.

8*a*. Associated free cheek. Natural size. U. S. Nat. Mus., Cat. No. 58535.

8*b*. Fragment of cephalon and thorax, showing free cheek in place and the nodes deflecting inner end of pleural groove forward so as to make groove almost oblique. Natural size. U. S. Nat. Mus., Cat. No. 58536.

8*c*. A very well-preserved pygidium associated with the other specimens illustrated. Natural size. U. S. Nat. Mus., Cat. No. 58537.

The species of *Olenoides* from the Middle Cambrian beds of the Coosa Valley, Alabama, United States, is illustrated to show the differences between *Olenoides* and *Dorypyge*.



COCKAYNE—BOSTON

Description of Plate 9.

Teinistion lansi Monke (p. 111).

1. Cranidium of a typical specimen. [After Monke, 1903, plate IV, fig. 2.]
1*a*. Enlargement of cranidium of a very young individual, showing a slightly arched frontal margin, instead of concave margin as in fig. 1. [After Monke, 1903, plate IV, fig. 5.]
1*b*. Free cheek. [After Monke, 1903, plate IV, fig. 7.]

Teinistion typicalis (Walcott) (p. 111).

2 and 2*a*. Parts of cranidium of two specimens showing variations in detail of frontal rim, × 8. U. S. Nat. Mus., Cat. Nos. 57892 and 57893.
2*b*. Associated free cheek, × 6. U. S. Nat. Mus., Cat. No. 57894.
2*c*. Associated pygidium, × 6. U. S. Nat. Mus., Cat. No. 57895.

The four specimens illustrated are from Locality C 12, Middle Cambrian, Kiu-lung group, southwest of Yen-chuang, Shan-tung.

Teinistion alcon (Walcott) (p. 110).

3. Type specimen of portion of cranidium, × 2. From Locality C 12, Middle Cambrian, Kiu-lung group, southwest of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 57896.

Teinistion ? sp. undt. Walcott (p. 222).

4. Pygidium doubtfully referred to this genus, × 4. From Locality C 54, Upper Cambrian, Ch'au-mi-tién limestone, west of Tsi-nan, Shan-tung. U. S. Nat. Mus., Cat. No. 57897.

Blackwelderia sinensis (Bergeron) (p. 121).

5, 5*a*, and 5*b*. Three specimens of cranidium showing variations in frontal margin and glabella. Natural size. U. S. Nat. Mus., Cat. Nos. 57898, 57899, 57900, respectively.
5*c*. Associated free cheek. Natural size. U. S. Nat. Mus., Cat. No. 57901.
5*d*. Associated hypostoma, × 2. U. S. Nat. Mus., Cat. No. 57902.
5*e*. Associated pygidium referred to this species. Natural size. U. S. Nat. Mus., Cat. No. 57903.
5*f*. Associated thoracic segment, × 1.5. U. S. Nat. Mus., Cat. No. 57904.
5*g*. Small pygidium supposed to belong to this species. U. S. Nat. Mus., Cat. No. 57905.

All of the specimens illustrated are from Locality C 6, Middle Cambrian, Kiu-lung group, southwest of Yen-chuang, except those represented by figs. 5*a*, 5*f*, and 5*g*, from Locality C 55, in isolated hills 380 feet (114 m.) above the Wön-ho, 12 miles (19 km.), south 80° east of Tsi-nan, Shan-tung.

Blackwelderia cilix (Walcott) (p. 119).

6. Broken cranidium. Natural size. From Locality C 73, Middle Cambrian, Ki-chóu limestone east of Fang-lan-chön, Shan-si. U. S. Nat. Mus., Cat. No. 57907.
6*a*. Associated free cheek. Natural size. U. S. Nat. Mus., Cat. No. 57908.
6*b*. Associated pygidium. Natural size. U. S. Nat. Mus., Cat. No. 57909.
6*c*. Pygidium from Locality C 55, Middle Cambrian, Ch'au-mi-tién limestone, south of Tsi-nan, Shan-tung. U. S. Nat. Mus., Cat. No. 57910.

Blackwelderia alastor (Walcott) (p. 117).

7. Type specimen, showing a fragment of cranidium, × 7. U. S. Nat. Mus., Cat. No. 57911.
7*a*. Associated pygidium referred to this species, × 1.5. From Locality C 12, Middle Cambrian, Kiu-lung group, southwest of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 57912.

Damesella bellagranulata Walcott (p. 125).

8. Type specimen of cranidium, × 1.5. From Locality C 13, Middle Cambrian, Kiu-lung group, southwest of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 57913.
8*a*. Under side of free cheek (× 2) on the same slab of rock as the specimen represented by fig. 8. Doubtfully referred to the species. U. S. Nat. Mus., Cat. No. 57914.
8*b*. Free cheek associated with and referred to this species, × 1.5. U. S. Nat. Mus., Cat. No. 57915.

Damesella brevicaudata Walcott (p. 128).

9. Top and side views of type specimen of pygidium, × 2. From Locality C 19, Middle Cambrian, Ch'ang-hia limestone at Ch'ang-hia, Shan-tung. U. S. Nat. Mus., Cat. No. 57916.

Damesella sp. undt. (*a*) Walcott.

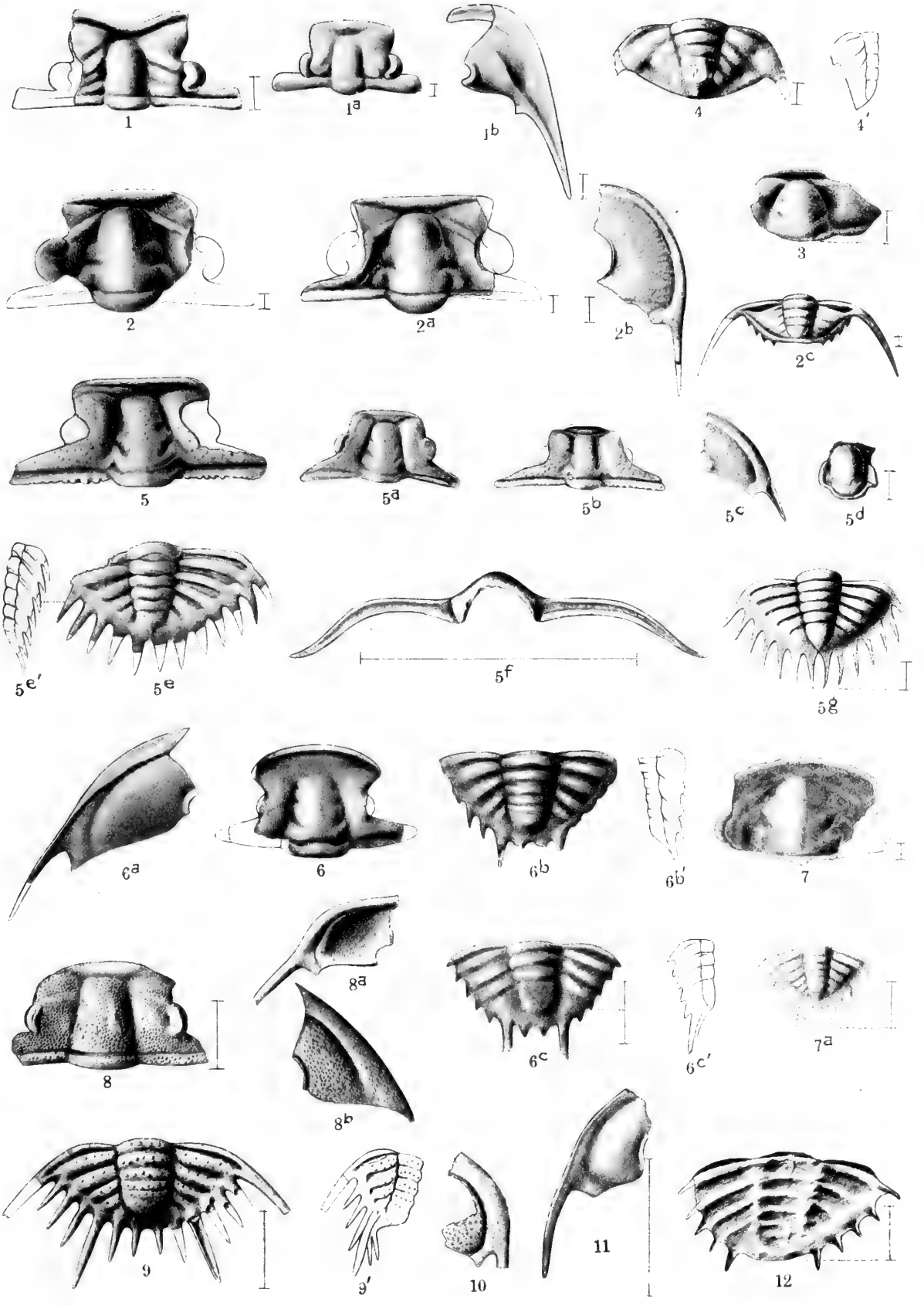
10. Fragment of free cheek. Natural size. From Locality C 46, Middle Cambrian, Ch'ang-hia limestone at Ch'au-mi-tién, Shan-tung. U. S. Nat. Mus., Cat. No. 57917.

Damesella sp. undt. (*b*) Walcott.

11. Free cheek, × 1.5, from same limestone as the specimen represented by fig. 10. (C 46). U. S. Nat. Mus., Cat. No. 57918.

Damesella sp. undt. (*c*) Walcott (p. 128).

12. Matrix of pygidium described. From Locality 350, Middle Cambrian, Fu-chóu series, Liau-tung, Manchuria. U. S. Nat. Mus., Cat. No. 57919.



COCKAYNE—BOSTON

Description of Plate 10.

Damesella blackwelderi Walcott (p. 125).

1. Cranidium drawn from three imperfect specimens. Natural size. U. S. Nat. Mus., Cat. No. 57920.
1*a*. Associated free cheek. U. S. Nat. Mus., Cat. No. 57921.
1*b*. Outline of side view of specimen represented by fig. 1. U. S. Nat. Mus., Cat. No. 57920.
1*c*. Cranidium with more coarsely granulated surface. Natural size. From Locality C 13 (same general locality as C 12), Middle Cambrian, Kiu-lung group, yellow slabby limestone 6 miles (9.6 km.) southwest of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 57922.
1*d*. Free cheek associated with head represented by fig. 1*c*. U. S. Nat. Mus., Cat. No. 57923.
1*e*. Pygidium associated. U. S. Nat. Mus., Cat. No. 57924.
1*f*. Pygidium associated. U. S. Nat. Mus., Cat. No. 57925.
1*g*. Thoracic segment associated. U. S. Nat. Mus., Cat. No. 57926.
1*h*. Interior of head and thorax. Natural size. From Locality C 14 (same general locality as C 12), Middle Cambrian, Kiu-lung group, southwest of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 57928.
1*i*. Hypostoma associated. U. S. Nat. Mus., Cat. No. 57929.
1*j*. Pygidium with very strong spines, associated with fig. 1. U. S. Nat. Mus., Cat. No. 57927.

All of the specimens illustrated, except those represented by figs. 1*c*, 1*d*, and 1*h*, are from Locality C 12, Middle Cambrian, Kiu-lung group, southwest of Yen-chuang, Shan-tung.

Drepanura premesnili Bergeron [see plate 11, figs. 1–5] (p. 129).

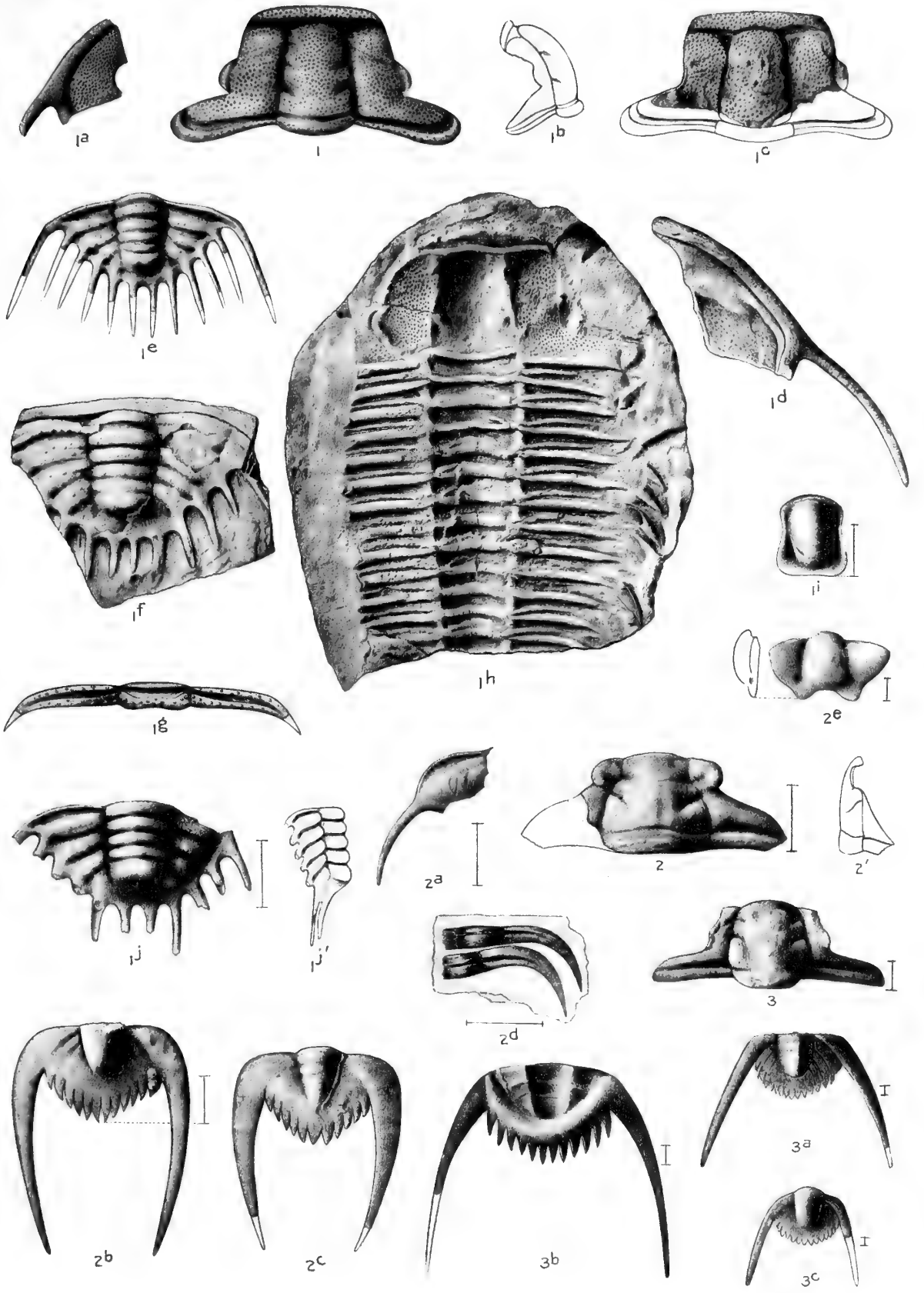
2. Top and side views of a typical form of the cranidium. From Locality C 55, Middle Cambrian, Ch'au-mi-tién limestone, south 80° east of Tsi-nan, Shan-tung. U. S. Nat. Mus., Cat. No. 57932.
2*a*. Associated free cheek, × 2. U. S. Nat. Mus., Cat. No. 57933.
2*b* and 2*c*. Typical forms of the pygidium, 2*b* × 2; 2*c* natural size. U. S. Nat. Mus., Cat. Nos. 57934 and 57935.
2*d*. Two thoracic segments showing part of axial lobe and pleural lobe, × 1.5. U. S. Nat. Mus., Cat. No. 57936.

The specimens represented by figs. 2*a–d* are from Locality C 6, Middle Cambrian, Kiu-lung group, southwest of Yen-chuang, Shan-tung.

2*e*. Associated hypostoma referred to this species, × 3. (C 6.) U. S. Nat. Mus., Cat. No. 57937.

Drepanura ketteleri Monke (p. 129).

3. Central parts of the cephalon, × 3. From Locality C 55, Middle Cambrian, Ch'au-mi-tién, east of Tsi-nan, Shan-tung. U. S. Nat. Mus., Cat. No. 57939.
3*a* and 3*c*. Small pygidia enlarged, × 7. Associated with fig. 3. U. S. Nat. Mus., Cat. Nos. 57940 and 57941.
3*b*. View of under side of a small pygidium, × 5. From Locality C 6, Middle Cambrian, Kiu-lung group, 2.5 miles (4 km.) southwest of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 57942.



COCKAYNE—BOSTON

Description of Plate 11.

Surface of slab of limestone from Locality C 6, Middle Cambrian, thin platy limestone in the upper shale member of the Kiu-lung group, 2.5 miles (4 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung. U. S. Nat. Mus., Cat. No. 57943.

Drepanura premesnili Bergeron [see plate 10, figs. 2, 2*a–d*] (p. 129).

1. Pygidia.
2. Segments of the thorax.
3. Cranidium.
4. Free cheek.
5. Hypostoma.

Agnostus douvilléi Bergeron [see plate 7, figs. 3, 3*a–b*, 8, 8*a*] (p. 100).

6. Pygidium.
7. Cephalon.

Liostracina krausei Monke [see plate 14, figs. 2, 2*a*] (p. 143).

8. Cranidium.

Shantungia spinifera Walcott [see plate 14, figs. 6, 6*a–e*] (p. 148).

9. Cranidium.
10. Free cheeks.

Description of Plate 12.

Albertella helena Walcott.

1. A nearly entire dorsal shield, from near summit of Lower Cambrian of Montana. [After Walcott, 1908*b*, plate 2, fig. 1.] U. S. Nat. Mus., Cat. No. 53410.

Albertella bosworthi Walcott.

2. Pygidium from Lower Cambrian, Mount Bosworth, British Columbia, Canada. [After Walcott, 1908*b*, plate 1, fig. 6.] U. S. Nat. Mus., Cat. No. 53415.

Albertella pacifica Walcott (p. 106).

3. Fragment of pygidium, × 2. From Locality 35f, Middle Cambrian, Fu-chóu series, on island of Tschang-hsing-tau, Liau-tung, Manchuria. U. S. Nat. Mus., Cat. No. 57568.

Ptychoparia striata Emmrich.

4. Specimen of the genotype of the genus *Ptychoparia* inserted as a means of comparison with the species from China. [After Barrande, 1852, plate 29, fig. 39.]

Ptychoparia kochibei Walcott (p. 132).

5. Dorsal shield (× 4) compressed in argillaceous shale. U. S. Nat. Mus., Cat. No. 57569.

5*a*. Small dorsal shield (× 6) associated with specimen represented by fig. 5. U. S. Nat. Mus., Cat. No. 57944.

5*b*. Cranidium in limestone, × 4. U. S. Nat. Mus., Cat. No. 57570.

5*c*. Cranidium in limestone, × 2, and side profile. U. S. Nat. Mus., Cat. No. 57945.

5*d*. Two specimens of cranidium on broken surface of limestone (× 2). U. S. Nat. Mus., Cat. No. 57946.

The specimens represented by figs. 5*b* and 5*c* are from Locality 35r, and fig. 5*d* is from Locality 35n, Middle Cambrian, Fu-chóu series, collected in a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria.

5*e*. Limestone with cranidia of various sizes attached to outer surface. Natural size. U. S. Nat. Mus., Cat. No. 57947.

The specimens represented by figs. 5, 5*a*, and 5*e* are from Locality 36e, Middle Cambrian, Fu-chóu series, Liau-tung, Manchuria.

Ptychoparia kingi Meek.

6. Dorsal shield (× 3) for comparison with *P. kochibei* (figs. 5 and 6). From Locality 3s, Middle Cambrian, Wheeler formation, Antelope Springs, Utah. U. S. Nat. Mus., Cat. No. 58292.

Ptychoparia granosa Walcott (p. 131).

7. Top and side views, × 3. From Locality C17, Lower Cambrian, Ch'ang-hia, Shan-tung. U. S. Nat. Mus., Cat. No. 57602.

Ptychoparia aclis Walcott (p. 130).

8. Type specimen of portion of central parts of cephalon, with outline of palpebral lobes restored. From Locality C17, Lower Cambrian, Ch'ang-hia, Shan-tung. U. S. Nat. Mus., Cat. No. 57948.

8*a*. Pygidium associated with cranidia of this species. From Locality C20, Lower Cambrian, Man-t'o shale, 1 mile (1.6 km.) south of Ch'ang-hia, Shan-tung. U. S. Nat. Mus., Cat. No. 57949.

Ptychoparia impar Walcott (p. 131).

9. Type specimen of central parts of cephalon, with side outline of same. From Locality C17, Lower Cambrian, Ch'ang-hia, Shan-tung, U. S. Nat. Mus., Cat. No. 57950.

9*a*. Associated free cheek. U. S. Nat. Mus., Cat. No. 57951.

Ptychoparia impar var. ? Walcott (p. 132).

10. Type specimen of central parts of cephalon, with side outline of same. From Locality C8, Middle Cambrian, southwest of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 57952.

Ptychoparia ligea Walcott (p. 133).

11. Type specimen showing central parts of cephalon. From Locality C31, Lower Cambrian, Ch'ang-hia, Shan-tung. U. S. Nat. Mus., Cat. No. 57953.

Ptychoparia lilia Walcott (p. 133).

12. Type specimen of central parts of cephalon, with side outline of same. From Locality C75, Middle Cambrian, south of Wu-t'ai-hién, Shan-si. U. S. Nat. Mus., Cat. No. 57954.

12*a*. Associated free cheek. U. S. Nat. Mus., Cat. No. 57955.

Ptychoparia ? tolus Walcott (p. 134).

13. Summit and side views of the type specimen. From Locality C52, Middle Cambrian, northwest of Sin-t'ai-hién, Shan-tung. U. S. Nat. Mus., Cat. No. 57956.

Ptychoparia typus (Dames) (p. 134).

14 and 14*a*. Central portions of cephalon flattened and distorted in argillaceous shale. From Locality 35o, Middle Cambrian, Fu-chóu series, Liau-tung, Manchuria. U. S. Nat. Mus., Cat. Nos. 57957 and 57958.

14*b*. Associated free cheek. U. S. Nat. Mus., Cat. No. 57959.

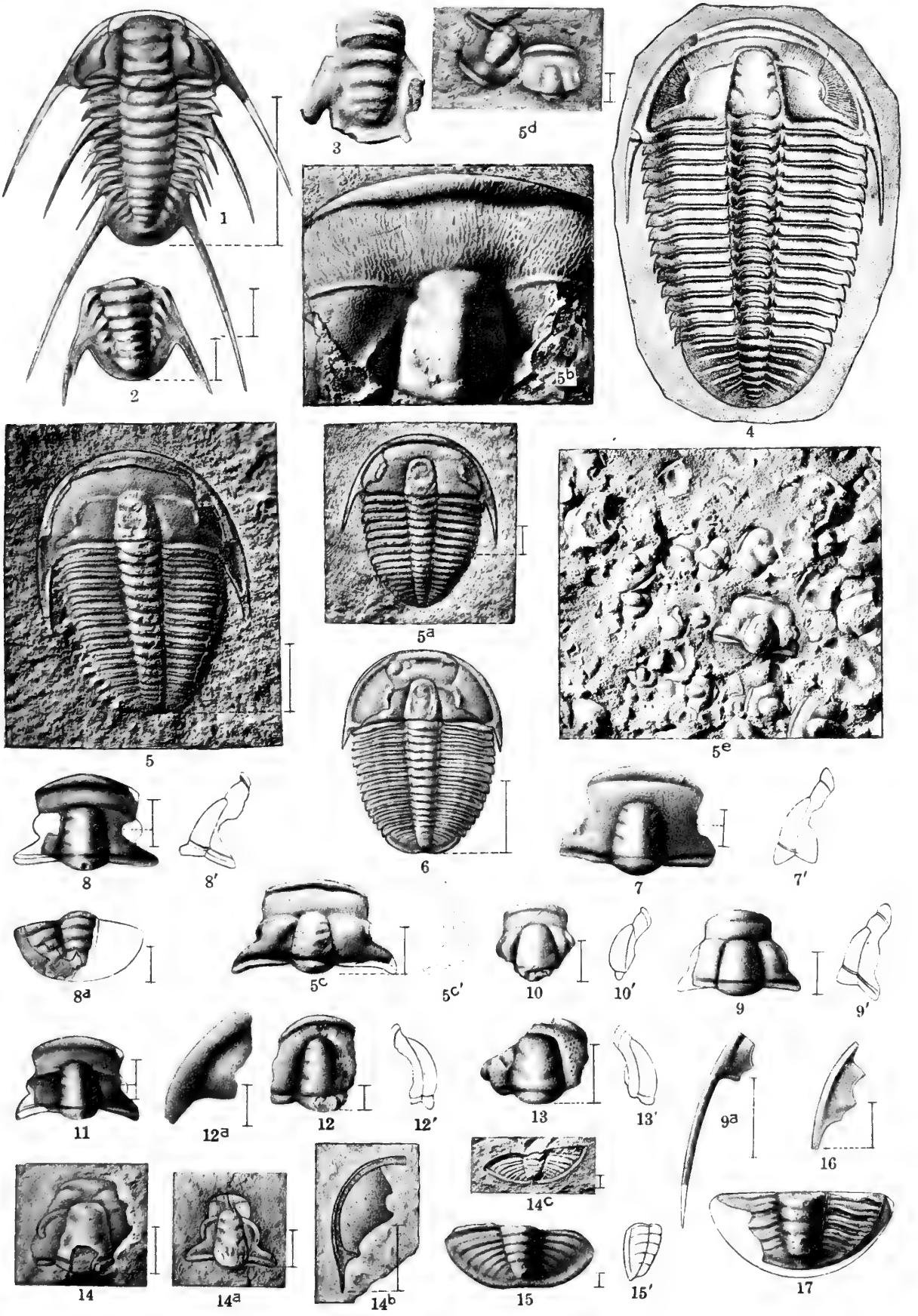
14*c*. Associated pygidium. U. S. Nat. Mus., Cat. No. 57960.

Ptychoparia spp. undt. (*a*), (*b*), and (*c*) Walcott (p. 222).

15. (*a*) Minute pygidium, and side outline, from C4, Middle Cambrian, the Ch'ang-hia limestone, 3 miles (4.8 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung. No cephalon to which this could be referred occurs in association with it. U. S. Nat. Mus., Cat. No. 57961.

16. (*b*) Free cheek from Ch'ang-hia limestone, C5, Middle Cambrian, 3.2 miles southwest of Yen-chuang, Sin-t'ai district, Shan-tung. There is no associated cephalon to which this free cheek can be referred. U. S. Nat. Mus., Cat. No. 57962.

17. (*c*) Large pygidium of unknown specific relations from Locality C58, Middle Cambrian, Ch'ang-hia limestone, 2 miles (3.2 km.) south-southwest of Kao-kia-p'u, Shan-tung. There are no associated cephala to which it can be referred. U. S. Nat. Mus., Cat. No. 57963.



COCKAYNE—BOSTON

Description of Plate 13.

Ptychoparia (Emmrichella) mantoensis (Walcott) (p. 136).

1. Type specimen showing central part of cephalon, exclusive of postero-lateral limbs; and side outline of same, × 1.5. U. S. Nat. Mus., Cat. No. 57964.

1*a* (× 2) and 1*b* (× 2). Associated free cheeks. U. S. Nat. Mus., Cat. Nos. 57965 and 57966.

1*c*. Associated pygidium, × 3. U. S. Nat. Mus., Cat. No. 57967.

All of the specimens represented by figs. 1, 1*a–c* are from Locality C 20, Lower Cambrian, south of Ch'ang-hia, Shan-tung.

Ptychoparia (Emmrichella) theano (Walcott) (p. 136).

2. Top and side views of type specimen, × 3. From Locality C 23, Middle Cambrian, southeast of Ch'ang-hia, Shan-tung. U. S. Nat. Mus., Cat. No. 57603.

Ptychoparia (Emmrichella) bromus (Walcott) (p. 135).

3. Type specimen, showing central parts of cephalon, × 2. From Locality C 6, Middle Cambrian, southwest of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 57969.

Ptychoparia (Emmrichella) eriopia (Walcott) (p. 136).

4. Top and side views of type specimen, showing central parts of cephalon, × 2. U. S. Nat. Mus., Cat. No. 57970.

4*a*. Pygidium associated with specimen represented by fig. 4, × 2. U. S. Nat. Mus., Cat. No. 57971.

From Locality C 23, Middle Cambrian, 1 mile (1.6 km.) east-southeast of Ch'ang-hia, Shan-tung.

Ptychoparia (Emmrichella) constricta (Walcott) (p. 135).

5. Type specimen, showing central parts of cephalon, except postero-lateral limbs. U. S. Nat. Mus., Cat. No. 57972.

5*a*. Associated pygidium. U. S. Nat. Mus., Cat. No. 57973.

The specimens represented by figs. 5 and 5*a* are from Locality C 3, Lower Cambrian, Man-t'o shale formation, Hu-lu-shan, southwest of Yen-chuang, Sin-t'ai district, Shan-tung.

Liostracus aculeatus Angelin.

6, 6*a*, and 6*b*. Dorsal side and front views of a specimen from Borgholm, Sweden, × 3. U. S. Nat. Mus., Cat. No. 58293.

Conocephalites emmrichi Barrande.

7 and 7*a*. Dorsal and side views of dorsal shield. [After Barrande, Syst. Sil. de Bohême, 1852, vol. 1, plate 11, figs. 4, 5.]

Conocephalites ornatus Brögger.

8. Central portion of cephalon. [After Brögger, Nyt Mag. Naturvid. vol. 24, 1877, plate 3, fig. 5.]

Conokephalina vesta (Walcott) (p. 139).

9. Dorsal and side views of the cranidium, × 4. U. S. Nat. Mus., Cat. No. 57974.

9*a*. Associated free cheek, × 2. U. S. Nat. Mus., Cat. No. 57975.

9*b* (× 3) and 9*c* (× 2). Associated pygidia. U. S. Nat. Mus., Cat. Nos. 57976 and 57977.

The specimens illustrated by figs. 9, 9*a–c* are from Locality C 69, Middle Cambrian, east of Fang-lan-chön, Shan-si.

Conokephalina sp. undt. (Walcott) (p. 140).

10. Dorsal and side views of a small cranidium, × 5. From Locality C 70, Middle Cambrian, south-southwest of Tung-yü, Shan-si. U. S. Nat. Mus., Cat. No. 57978.

Conokephalina dryope (Walcott) (p. 138).

11. Dorsal and side views of a broken cranidium, × 2. U. S. Nat. Mus., Cat. No. 57979.

11*a*. Associated free cheek, × 3. U. S. Nat. Mus., Cat. No. 57980.

11*b*. Dorsal and side views of an associated pygidium, × 2. U. S. Nat. Mus., Cat. No. 57981.

The three specimens illustrated are from Locality C 56, Upper Cambrian, 1 mile (1.6 km.) west of Tsi-nan, Shan-tung.

Conokephalina belus (Walcott) (p. 138).

12. Dorsal and side views of a cranidium, × 3. U. S. Nat. Mus., Cat. No. 57982.

12*a*. Dorsal and side views of an associated pygidium, × 3. U. S. Nat. Mus., Cat. No. 57983.

Both specimens illustrated are from Locality C 56, Upper Cambrian, 1 mile (1.6 km.) west of Tsi-nan, Shan-tung.

Conokephalina maia (Walcott) (p. 139).

13. Dorsal view of a small broken cranidium, × 5. From Locality C 70, Middle Cambrian, south-southwest of Tung-yü, Shan-si. U. S. Nat. Mus., Cat. No. 57984.

Crepicephalus damia Walcott (p. 141).

14. Type specimen, showing central parts of cephalon, and side outline of same, × 2. U. S. Nat. Mus., Cat. No. 57986.

14*a*. Associated free cheek, × 2. U. S. Nat. Mus., Cat. No. 57987.

14*b*. Associated pygidium, × 2. U. S. Nat. Mus., Cat. No. 57988.

The three specimens illustrated are from Locality C 18, Middle Cambrian, east of Ch'ang-hia, Shan-tung.

Crepicephalus magnus Walcott (p. 142).

15. Fragment of base of glabella, × 2. From Locality C 48, Middle Cambrian, Ch'au-mi-tién, Shan-tung. U. S. Nat. Mus., Cat. No. 57992.

15*a*. Fragment of a free cheek referred to this species on account of the coarse granulations. It is from Locality C 25, Middle Cambrian, Ch'ang-hia limestone, at Ch'ang-hia, Shan-tung. U. S. Nat. Mus., Cat. No. 57993.

15*b*. Cast of interior of a free cheek and spine, associated with the specimen represented by fig. 15. U. S. Nat. Mus., Cat. No. 57994.

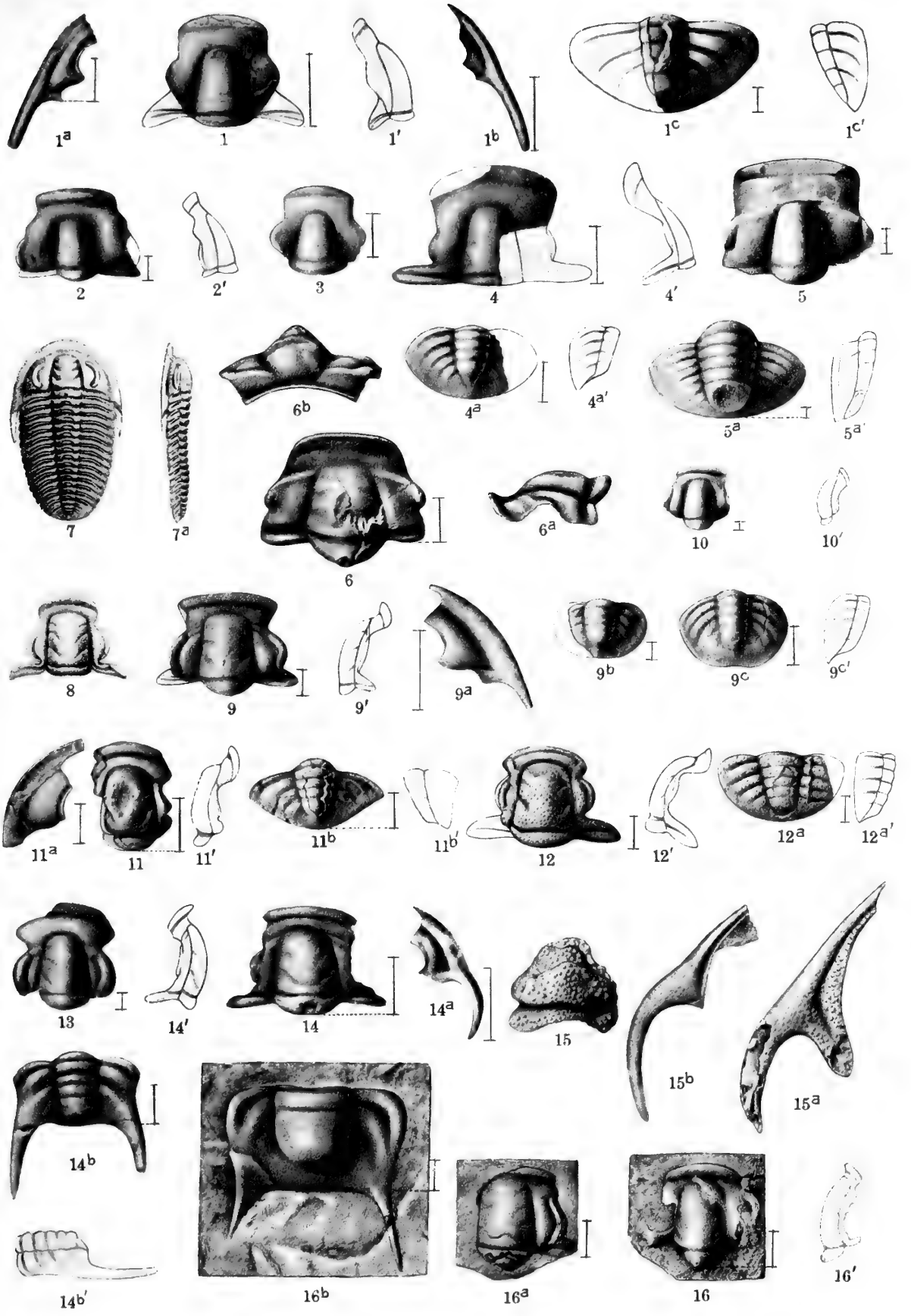
Figures 15 and 15*b* represent specimens from the lower portion of the Ch'au-mi-tién limestone at C 48, Middle Cambrian, Ch'au-mi-tién, Shan-tung.

Crepicephalus convexus Walcott (p. 140).

16 and 16*a*. Two specimens of cranidium and side outline of 16, × 3. U. S. Nat. Mus., Cat. Nos. 57996 and 57571, respectively.

16*b*. Dorsal view of pygidium and side outline, × 3. U. S. Nat. Mus., Cat. No. 57572.

The three specimens illustrated are from Locality 35 r, Middle Cambrian, Fu-chóu series, Liau-tung, Manchuria.



COCKAYNE—BOSTON

Description of Plate 14.

Lonchocephalus tellus (Walcott) (p. 143).

1. Dorsal view of type specimen of species, × 2. From Locality C2, Middle Cambrian, Kiu-lung formation, south of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 57997.

Liostracina krausei Monke [see plate 11, fig. 8] (p. 143).

2 and 2*a*. Central parts of the cephalon of two specimens showing variation in detail of glabella and fixed cheeks. From Locality C6, Middle Cambrian, Kiu-lung formation, southwest of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. Nos. 57998 and 57999.

Proampyx burea (Walcott) (p. 145).

3. Dorsal and side views of type specimen. From Locality C61, Upper Cambrian, Ch'au-mi-tién formation, southwest of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 58001.

Pterocephalus busiris Walcott (p. 146).

4. Top and side views of type specimen of pygidium. From Locality C61, Upper Cambrian, Kiu-lung group, southwest of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 58002.

Pterocephalus asiaticus Walcott (p. 146).

5. Fragment of central parts of cephalon. U. S. Nat. Mus., Cat. No. 58004.
5*a*. Fragment of pygidium. U. S. Nat. Mus., Cat. No. 58005.
5*b*. Fragment of spinose border of pygidium. U. S. Nat. Mus., Cat. No. 58006.
The three specimens illustrated are from Locality C12, Middle Cambrian, Kiu-lung formation, southwest of Yen-chuang, Shan-tung.

Shantungia spinifera Walcott [see plate 11, figs. 9, 10] (p. 148).

6. An elongate form of central portions of cephalon. U. S. Nat. Mus., Cat. No. 57807.
6*a*. Associated free cheek. U. S. Nat. Mus., Cat. No. 57808.
6*b*. A minute cephalon without the nasute projection in front. This may be a young cephalon of some other trilobite. U. S. Nat. Mus., Cat. No. 57809.
6*c*. Associated free cheek. U. S. Nat. Mus., Cat. No. 57810.
6*d*. A broad form of central parts of cephalon. U. S. Nat. Mus., Cat. No. 57811.
6*e*. A small cranidium without the anterior nasute projection × 4. U. S. Nat. Mus., Cat. No. 57812.
All of the specimens illustrated are from Locality C6, Middle Cambrian, Ku-shan formation, southwest of Yen-chuang, Shan-tung.

Protaspis gen. and sp. undt. Walcott.

7. Young trilobite (*Protaspis* stage) associated with *Shantungia spinifera, Stephanocare richthofeni,* and *Agnostus koerferi.* From Locality C6, Middle Cambrian, Ku-shan formation, southwest of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 58013.

Pterocephalus ? liches Walcott (p. 147).

8. Dorsal and side view of type specimen of pygidium, × 4. From Locality 35n, Middle Cambrian, Fu-chóu series, Liau-tung, Manchuria. U. S. Nat. Mus., Cat. No. 57573.

Inouyia titiana (Walcott) (p. 155).

9. Dorsal and side views of type specimen of cranidium, × 2. From Locality C7, Middle Cambrian, Ch'ang-hia formation, southwest of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 58015.

Inouyia ? inflata (Walcott) (p. 152).

10. Dorsal and side views of cranidium, × 2. From Locality C69, Middle Cambrian, Ki-chóu limestone, east of Fang-lan-chön, Shan-si. U. S. Nat. Mus., Cat. No. 58016.

Inouyia capax (Walcott) (p. 151).

11 and 11*a*. Dorsal and side views of typical forms of cranidium, × 3. From Locality C70, Middle Cambrian, Ki-chóu limestone, southwest of Tung-yü, Shan-si. U. S. Nat. Mus., Cat. Nos. 58017 and 58018.

Inouyia melie (Walcott) (p. 153).

12. Dorsal and side views of type specimen, showing central parts of cephalon, × 3. From Locality C70, Middle Cambrian, Ki-chóu limestone, south-southwest of Tung-yü, Shan-si. U. S. Nat. Mus., Cat. No. 57604.
12*a*. Dorsal and side views of a specimen with proportionately larger frontal limb, × 4. From Locality C75, Middle Cambrian, Ki-chóu formation, south of Wu-t'ai-hién, Shan-si. U. S. Nat. Mus., Cat. No. 58019.

Inouyia divi (Walcott) (p. 152).

13. Dorsal and side views of type specimen, showing central parts of cephalon, × 2. From Locality C5, Middle Cambrian, Kiu-lung formation, southwest of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 58020.
13*a*. Free cheek associated with specimen represented by fig. 13, × 4. U. S. Nat. Mus., Cat No. 58021.
14. *Protaspis* associated with this species, × 8. U. S. Nat. Mus., Cat. No. 58022.

Description of Plate 14—Continued.

Inouyia ? acalle (Walcott) (p. 150).

15. Dorsal view and side outline of type specimen, showing central parts of cephalon, × 5. From Locality C 12, Middle Cambrian, Kiu-lung formation, southwest of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 58023.

Inouyia abaris (Walcott) (p. 149).

16. Dorsal view and side outline of type specimen, showing central parts of cephalon, × 3. From Locality C 9, Middle Cambrian, Kiu-lung formation, southwest of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 58024.

Inouyia armata (Walcott) (p. 150).

17. Dorsal view and side outline of type specimen, showing central parts of cephalon, × 3. From Locality C 75, Middle Cambrian, Ki-chóu formation, south of Wu-t'ai-hién, Shan-si. U. S. Nat. Mus., Cat. No. 58026.

17*a*. Associated fragment preserving the anterior end of the glabella and the frontal limb and margin. U. S. Nat. Mus., Cat. No. 58027.

Inouyia ? regularis (Walcott) (p. 154).

18. Dorsal and side views of type specimen, showing central parts of cephalon, × 6. From Locality C 73, Middle Cambrian, Ki-chóu formation, east of Fang-lan-chön, Shan-si. U. S. Nat. Mus., Cat. No. 58028.

Levisia agenor (Walcott) (p. 178).

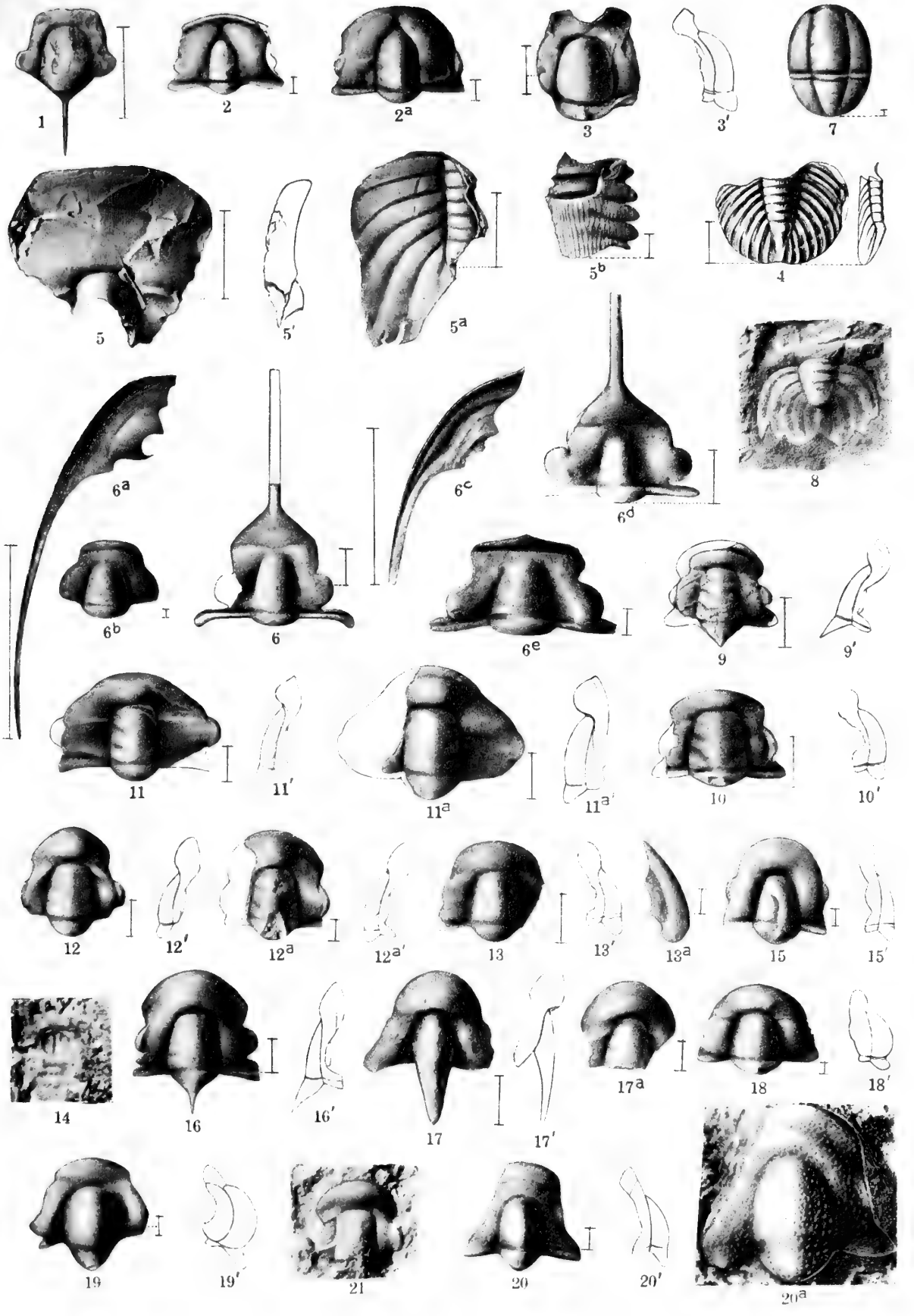
19. Dorsal view and side outline of type specimen, showing central parts of cephalon, × 5. From Locality C 25, Middle Cambrian, Ch'ang-hia formation at Ch'ang-hia, Shan-tung. U. S. Nat. Mus., Cat. No. 57610.

Agraulos dryas Walcott (p. 157).

20. Dorsal and side views of type specimen, showing central parts of cephalon, ×4. From Locality C 29, Middle Cambrian, Ch'ang-hia limestone, west of Ch'ang-hia, Shan-tung. U. S. Nat. Mus., Cat. No. 58030.

Inouyia thisbe Walcott (p. 154).

21. Dorsal view and side outline of the type specimen, × 3. From Locality C 28, Middle Cambrian, Ch'ang-hia limestone, east-southeast of Ch'ang-hia, Shan-tung. U. S. Nat. Mus., Cat. No. 57574.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Description of Plate 15.

Agraulos ceticephalus Barrande.

1. Two dorsal shields on a fragment of shale from Skrey, Bohemia. U. S. Nat. Mus., Cat. No. 18470.
1*a* and 1*b*. Dorsal and side views of an entire dorsal shield. [After Barrande, Syst. Sil. de Bohême. vol. I, 1852, plate 10, figs. 14 and 15.]
1*c*. Enlargement of two thoracic segments. [After Barrande, idem, fig. 16.]

Agraulos nitida Walcott (p. 158).

2. Dorsal and side views of type specimen, showing central parts of cephalon, × 3. U. S. Nat. Mus., Cat. No. 58031.
2*a* and 2*b*. Fragments of cranidia, showing variations in outline of glabella and frontal limb, × 3. U. S. Nat. Mus., Cat. Nos. 58032 and 58033.

The three specimens illustrated are from Locality C75, Middle Cambrian, Ki-chóu formation, south of Wu-t'ai-hién, Shan-si.

Agraulos abrota Walcott (p. 156).

3. Dorsal view and side outline of type specimen, showing central parts of cephalon, × 6. From Locality C23, Middle Cambrian, Ch'ang-hia formation, east-southeast of Ch'ang-hia, Shan-tung. U. S. Nat. Mus., Cat. No. 58034.

Agraulos obscura Walcott (p. 158).

4. Dorsal and side views of type specimen, showing central parts of cephalon, × 2.5. From Locality C69, Middle Cambrian, Ki-chóu limestone, east of Fang-lan-chön, Shan-si. U. S. Nat. Mus., Cat. No. 58035.

Agraulos dirce Walcott (p. 156).

5. Dorsal and side views of type specimen, showing central parts of cephalon, × 1.5. From Locality C52, Middle Cambrian, Ch'ang-hia formation, northeast of Sin-t'ai-hién, Shan-tung. U. S. Nat. Mus., Cat. No. 58036.

Agraulos dolon Walcott (p. 156).

6. Dorsal and side views of type specimen, showing central parts of cephalon, × 2. From Locality C7, Middle Cambrian, Ch'ang-hia formation, southwest of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 58037.

Agraulos uta Walcott (p. 159).

7. Dorsal and side views of type specimen, showing central parts of cephalon, × 3. From Locality C75, Middle Cambrian, Ki-chóu formation, south of Wu-t'ai-hién, Shan-si. U. S. Nat. Mus., Cat. No. 58038.

Agraulos vicina Walcott (p. 160).

8. Dorsal and side views of type specimen, showing central parts of cephalon, × 4. From Locality C70, Middle Cambrian, Ki-chóu limestone, south-southwest of Tung-yü, Shan-si. U. S. Nat. Mus., Cat. No. 58039.

Agraulos sorge Walcott (p. 159).

9. Dorsal and side views of type specimen of cranidium, × 4. From Locality 35n, Middle Cambrian, Fu-chóu series, Liau-tung, Manchuria. U. S. Nat. Mus., Cat. No. 57575.

Pagodia bia Walcott (p. 161).

10. Dorsal and side views of type specimen, showing central parts of cephalon, × 3. From Locality C56, Upper Cambrian, Ch'au-mi-tién formation, Pagoda Hill, west-southwest of Tsi-nan, Shan-tung. U. S. Nat. Mus., Cat. No. 58040.
10*a*. Associated pygidium referred to this species. U. S. Nat. Mus., Cat. No. 58041.

Pagodia dolon Walcott (p. 161).

11. Dorsal and side views of type specimen, showing central parts of cephalon, × 4. From Locality C41, Middle Cambrian, Ch'au-mi-tién formation, southwest of Ch'au-mi-tién, Shan-tung. U. S. Nat. Mus., Cat. No. 58042.

Pagodia lotos Walcott (p. 162).

12. The type specimen, showing central parts of cephalon, × 2. From Locality C56, Upper Cambrian, Ch'au-mi-tién formation, Pagoda Hill, west-southwest of Tsi-nan, Shan-tung. U. S. Nat. Mus., Cat. No. 58043.
12*a*. Associated pygidium referred to this species, × 4. U. S. Nat. Mus., Cat. No. 58044.

Pagodia macedo Walcott (p. 163).

13. Dorsal and side views of type specimen, showing central parts of cephalon, × 2. From Locality C34, Upper Cambrian, Ch'au-mi-tién formation, Ch'au-mi-tién, Shan-tung. U. S. Nat. Mus., Cat. No. 58045.

Description of Plate 15—Continued.

Lisania cf. bura (Walcott) (p. 166).

14. Dorsal view and side outline of central parts of cephalon, × 4. From Locality C77, Middle Cambrian, Ki-chóu formation, southeast of Yau-t'o near Wu-t'ai-hién, Shan-si. U. S. Nat. Mus., Cat. No. 58046.

Lisania bura (Walcott) (p. 166).

15. Dorsal view and side outline of type specimen, showing central parts of cephalon, × 5. From Locality C22, Middle Cambrian, Ch'ang-hia limestone, Ch'ang-hia, Shan-tung. U. S. Nat. Mus., Cat. No. 57605.

Lisania ? belenus (Walcott) (p. 166).

16. Dorsal and side views of type specimen, showing central parts of cephalon, × 4. From Locality C19, Middle Cambrian, Ch'ang-hia limestone, Ch'ang-hia, Shan-tung. U. S. Nat. Mus., Cat. No. 58047.

Lisania agonius (Walcott) (p. 164).

17. Dorsal and side views of central parts of cephalon, × 4. From Locality C1, Middle Cambrian, Kiu-lung group, south of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 58048.

17*a*. Free cheek, × 3. From Locality C2 (same as C1 but a little above it in the section). U. S. Nat. Mus., Cat. No. 58049.

Lisania ajax (Walcott) (p. 165).

18. Dorsal and side views of type specimen, showing central parts of cephalon, × 4. From Locality C12, Middle Cambrian, Kiu-lung group, southwest of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 58050.

18*a*. Free cheek, × 4. From Locality C40, about the same horizon and locality (C12) as above. U. S. Nat. Mus., Cat. No. 58051.

Lisania alala (Walcott) (p. 165).

19. Fragment of central parts of cephalon, and side outline, × 4. U. S. Nat. Mus., Cat. No. 58052. (C51.)

19*a*. Fragment of central parts of cephalon, differing somewhat from specimen represented by fig. 19, × 4. From Locality C4, Middle Cambrian, Kiu-lung group, southwest of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 58055.

19*b*. Free cheek referred to this species, × 3. (C51.) U. S. Nat. Mus., Cat. No. 58053.

19*c* (× 4, C51) and 19*d* (× 4). Top and side views of pygidia referred to this species. From Locality C22, Middle Cambrian, Ch'ang-hia limestone, Ch'ang-hia, Shan-tung. U. S. Nat. Mus., Cat. Nos. 58054 and 58056.

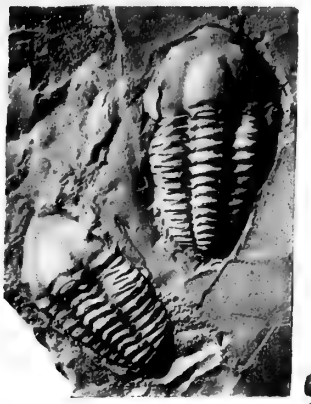
The specimens represented by figs. 19, 19*b*, and 19*c* are from Locality C51, Middle Cambrian, Ch'ang-hia formation, Ch'au-mi-tién, Shan-tung.

Lisania sp. undt. (*a*) Walcott (p. 167).

20. Dorsal and side views of pygidium from Locality C30, Middle Cambrian, Ch'ang-hia limestone, Ch'ang-hia, Shan-tung. U. S. Nat. Mus., Cat. No. 58060.

Lisania sp. undt. (*b*) Walcott (p. 167).

21. Dorsal and side views of a pygidium from Locality C41, Middle Cambrian, Ch'au-mi-tién limestone, near Ch'au-mi-tién, Shan-tung. U. S. Nat. Mus., Cat. No. 58061.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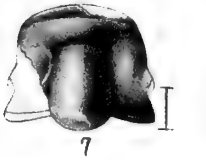
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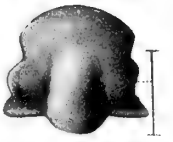
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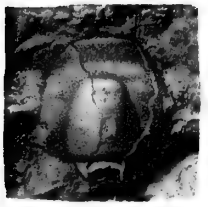
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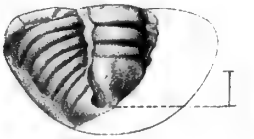
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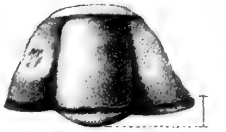
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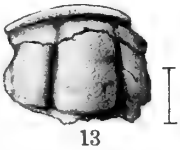
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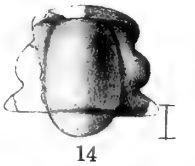
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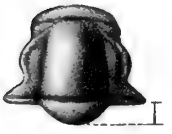
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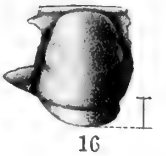
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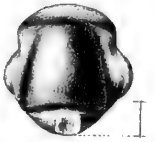
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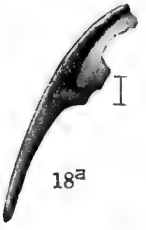
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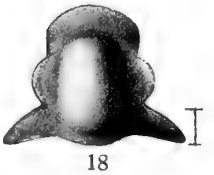
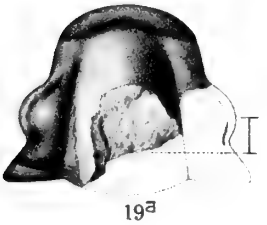

18

18′

19

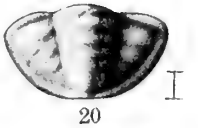
19′


19a

19b

19c

19c′


20

20′

19d

19d′

21

21′

COCKAYNE—BOSTON

Description of Plate 16.

Chuangia nais Walcott (p. 171).

1. Dorsal view and side outline of a fragmentary specimen of the central parts of a cephalon. Natural size. From Locality C 64, Upper Cambrian, Kiu-lung group, southwest of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 57608.

Chuangia fragmenta Walcott (p. 171).

2. Dorsal view and side outline of a fragmentary specimen of central parts of a cephalon, × 1.5. From Locality C 61, Upper Cambrian, Kiu-lung group, southwest of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 57607.

Menocephalus abderus (Walcott) (p. 173).

3. Type specimen showing portions of central parts of cephalon; and side outline of same, × 2. From Locality C 19, Middle Cambrian, Ch'ang-hia limestone, at Ch'ang-hia, Shan-tung. U. S. Nat. Mus., Cat. No. 58076.

Menocephalus acanthus Walcott (p. 173).

4. Type specimen, showing portions of central parts of cephalon; and side outline of same, × 3. From Locality C 22, Middle Cambrian, Ch'ang-hia limestone, at Ch'ang-hia, Shan-tung. U. S. Nat. Mus., Cat. No. 58077.

4*a*. Fragment showing form of palpebral lobe and postero-lateral glabellar lobes of a cephalon associated with the specimen represented by fig. 4, × 4. (C 22.) U. S. Nat. Mus., Cat. No. 58078.

4*b*. Associated pygidium, × 3. (C 22.) U. S. Nat. Mus., Cat. No. 58079.

Levisia adrastia (Walcott) (p. 177).

5. Top and side views of type specimen, × 4. From Locality C 30, Middle Cambrian, Ch'ang-hia limestone at Ch'ang-hia, Shan-tung. U. S. Nat. Mus., Cat. No. 58084.

5*a*. Associated fragment of a cephalon. (C 30.) U. S. Nat. Mus., Cat. No. 58085.

Menocephalus ? depressus Walcott (p. 176).

6. Top and side views of type specimen, × 4. From Locality C 56, Upper Cambrian, Ch'au-mi-tién formation west of Tsi-nan, Shan-tung. U. S. Nat. Mus., Cat. No. 58080.

6*a*. Free cheek (× 2) associated with this species at Locality C 49, Upper Cambrian, Ch'au-mi-tién limestone, west-southwest of Ch'au-mi-tién, Shan-tung. U. S. Nat. Mus., Cat. No. 58081.

Menocephalus ? sp. undt. Walcott (p. 176).

7. A small cephalon doubtfully referred to this genus, × 3. From Locality C 10, Middle Cambrian, Kiu-lung group, southwest of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 58082.

7*a*. Associated fragment of glabella and fixed cheeks, × 4. U. S. Nat. Mus., Cat. No. 58083.

Menocephalus acidalia Walcott (p. 174).

8. Type specimen showing portions of central parts of cephalon; and side outline of same, × 4. From Locality C 30, Middle Cambrian, Ch'ang-hia limestone, at Ch'ang-hia, Shan-tung. U. S. Nat. Mus., Cat. No. 58086.

8*a*. Associated free cheek, × 1.5. U. S. Nat. Mus., Cat. No. 58087.

Menocephalus agave Walcott (p. 176).

9. Top and side views of type specimen, × 3. From Locality C 30, Middle Cambrian, Ch'ang-hia limestone, at Ch'ang-hia, Shan-tung. U. S. Nat. Mus., Cat. No. 58088.

Menocephalus acerius Walcott (p. 174).

10. Top and side views of type specimen, × 2. From Locality C 18, Middle Cambrian, Ch'ang-hia limestone, east of Ch'ang-hia, Shan-tung. U. S. Nat. Mus., Cat. No. 58089.

10*a*. Free cheek, × 2. Associated with fig. 10. This occurs on a piece of limestone beside the pygidium of *Crepicephalus damia*, plate 13, fig. 14. U. S. Nat. Mus., Cat. No. 58090.

Menocephalus acis Walcott (p. 175).

11. Top and side views of type specimen, × 4. From Locality C 35, Middle Cambrian, Ch'ang-hia limestone, at Ch'au-mi-tién, Shan-tung. U. S. Nat. Mus., Cat. No. 58091.

Menocephalus admeta Walcott (p. 175).

12. Top and side views of a minute cephalon doubtfully referred to this genus, × 6. From Locality C 22, Middle Cambrian, Ch'ang-hia limestone, at Ch'ang-hia, Shan-tung. U. S. Nat. Mus., Cat. No. 58092.

Ptychaspis calchas Walcott (p. 183).

13 (Natural size) and 13*a* (× 1.5). Fragmentary specimens of glabella and palpebral lobes. From Locality C 41, Upper Cambrian, Ch'au-mi-tién limestone, southwest of Ch'au-mi-tién, Shan-tung. U. S. Nat. Mus., Cat. Nos. 58093 and 58094, respectively.

Ptychaspis callisto Walcott (p. 183).

14. Type specimen showing portions of central parts of cephalon; and side outline of same, × 1.5. From Locality C 64, Upper Cambrian, Kiu-lung group, southwest of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 58095.

14*a*. Associated free cheek, × 1.5. U. S. Nat. Mus., Cat. No. 58096.

Description of Plate 16—Continued.

Ptychaspis calyce Walcott (p. 184).

15 (× 3, C64) and 15*a* (natural size, C42). Fragments of central parts of cephalon, showing glabella, occipital ring, and frontal rim; with side outlines of same. Fig. 15 is from Locality C64, the same as fig. 14, Upper Cambrian, Kiu-lung group, southwest of Yen-chuang, Shan-tung. Fig. 15*a* is from Locality C42, the same as fig. 16, Upper Cambrian, Ch'au-mi-tién limestone, east of Ch'au-mi-tién, Shan-tung. U. S. Nat. Mus., Cat. Nos. 58097 and 58098, respectively.

Ptychaspis campe Walcott (p. 184).

16. Type specimen, showing portions of central parts of cephalon; and side outline of same, × 4. From Locality C42, Upper Cambrian, Ch'au-mi-tién limestone, east of Ch'au-mi-tién, Shan-tung. U. S. Nat. Mus., Cat. No. 58099.

Ptychaspis ceto Walcott (p. 185).

17. Type specimen, showing portions of central parts of cephalon. Natural size. From Locality C38, Upper Cambrian, Ch'au-mi-tién limestone at Ch'au-mi-tién, Shan-tung. U. S. Nat. Mus., Cat. No. 58100.

17*a*. Free cheek, natural size, associated with this species at Locality C54, Upper Cambrian, Ch'au-mi-tién limestone, west of Tsi-nan, Shan-tung. U. S. Nat. Mus., Cat. No. 58103.

17*b*. Free cheek, × 3. Associated with specimen represented by fig. 17. (C38.) U. S. Nat. Mus., Cat. No. 58101.

17*c*. Pygidium, × 1.5. Associated with specimens represented by figs. 17 and 17*b*. (C38.) U. S. Nat. Mus., Cat. No. 58102.

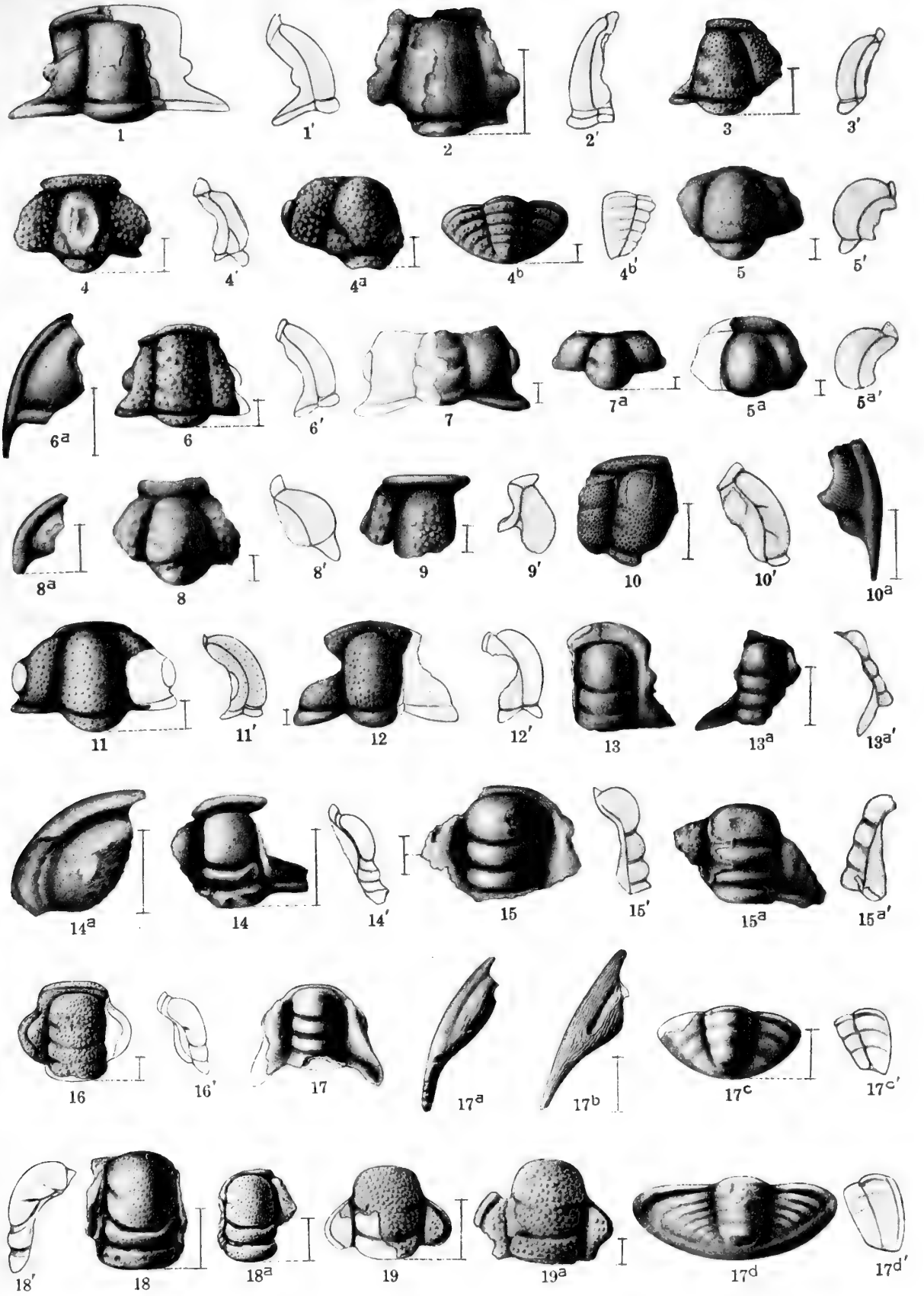
17*d*. Pygidium associated with this species at Locality C54 [see 17*a*], Upper Cambrian, Ch'au-mi-tién limestone, west of Tsi-nan, Shan-tung. U. S. Nat. Mus., Cat. No. 58104.

Ptychaspis acamus Walcott (p. 179).

18 and 18*a*. Fragments of the central parts of the cephalon, showing glabella, occipital ring, and narrow frontal rim; with side view of fig. 18, × 2. From Locality C45, Upper Cambrian, Ch'au-mi-tién limestone at Ch'au-mi-tién, Shan-tung. U. S. Nat. Mus., Cat. Nos. 58109 and 58110.

Ptychaspis cadmus Walcott (p. 182).

19 (× 1.5) and 19*a* (× 3). Fragmentary specimens of the glabella and palpebral lobes. From Locality C41, Upper Cambrian, Ch'au-mi-tién limestone, southwest of Ch'au-mi-tién, Shan-tung. U. S. Nat. Mus., Cat. Nos. 58111 and 58112.



COCKAYNE—BOSTON

Description of Plate 17.

Ptychaspis ? sp. undt. (*a*) Walcott [see plate 21, fig. 14] (p. 186).

1. Fragment of free cheek, natural size, from Locality C 64, Upper Cambrian, Kiu-lung group, 2.7 miles (4.3 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung. U. S. Nat. Mus., Cat. No. 58113.

Ptychaspis baubo (Walcott) (p. 179).

2. Fragment of central parts of cranidium. Natural size. From Locality C 64, Upper Cambrian, Kiu-lung group, 2.7 miles (4.3 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung. U. S. Nat. Mus., Cat. No. 58114.

2*a*. Associated free cheek. U. S. Nat. Mus., Cat. No. 58115.

Ptychaspis brizo (Walcott) (p. 181).

3. Anterior part of central portion of cranidium; with side outline. From Locality C 38, Upper Cambrian, Ch'au-mi-tién limestone, at Ch'au-mi-tién, Shan-tung. U. S. Nat. Mus., Cat. No. 58116.

3*a*. Free cheek from same formation and locality as specimen represented by fig. 3. U. S. Nat. Mus., Cat. No. 58117.

3*b*. Associated pygidium, × 2. U. S. Nat. Mus., Cat. No. 58118.

4 (× 1.5) and 5 (natural size). Large free cheeks associated with fig. 3. U. S. Nat. Mus., Cat. Nos. 58119 and 58120, respectively.

Ptychaspis ? sp. undt. (*b*) Walcott [see plate 21, fig. 15] (p. 186).

6. Fragment of large free cheek (natural size) from Locality C 54, Upper Cambrian, Ch'au-mi-tién limestone, two-thirds of a mile (1.1 km.) west of Tsi-nan, Shan-tung. U. S. Nat. Mus., Cat. No. 58121.

Ptychaspis ? sp. undt. (*c*) Walcott (p. 186).

7 (× 2, C 67) and 8 (× 2, C 33). Two free cheeks from widely separated localities that are of the same general type. The specimen represented by fig. 7 is from Locality C 67, Upper Cambrian, a fragment of limestone in the drift west of the wset city gate, Tsi-nan, Shan-tung. Fig. 8 is from Locality C 33, Upper Cambrian, the Ch'au-mi-tién limestone, 9 miles (14.5 km.) north of Sin-t'ai-hién, Shan-tung. U. S. Nat. Mus., Cat. Nos. 58122 and 58123, respectively.

Ptychaspis bella Walcott (p. 180).

9. Type specimen, showing portions of central parts of cephalon; and side outline of same, × 2. From Locality C 74, Upper Cambrian, Ki-chóu limestone, east of Fang-lan-chön, Shan-si. U. S. Nat. Mus., Cat. No. 58124.

Ptychaspis cacus Walcott (p. 181).

10. Fragment of free cheek associated with fig. 11, × 3. U. S. Nat. Mus., Cat. No. 58125.

11. Type specimen showing portions of central parts of cephalon, and side view of same. Natural size. From Locality C 64, Upper Cambrian, Kiu-lung group, southwest of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 58126.

Solenopleura holometopa Angelin (p. 167).

12. Dorsal view of a cranidium from which the tuberculated outer test has been exfoliated, × 1.25. U. S. Nat. Mus., Cat. No. 58294.

12*a* and 12*b*. Side and front views of specimen represented by fig. 1.

12*c*. Enlargement of granulated surface on free cheek, × 3. U. S. Nat. Mus., Cat. No. 58295.

The specimens illustrated are from the type locality of the species, Andrarum, Sweden.

Solenopleura chalcon Walcott (p. 168).

13. Dorsal view and side outline of cranidium, × 4. From Locality 35 r, Middle Cambrian, Fu-chóu series, Liau-tung, Manchuria. U. S. Nat. Mus., Cat. Nc. 57588.

Solenopleura beroe Walcott (p. 168).

14. Dorsal view and side outline of a small cranidium, × 3. From Locality 35 n, Middle Cambrian, Fu-chóu series, Liau-tung, Manchuria. U. S. Nat. Mus., Cat. No. 58066.

14*a*. Dorsal view of a cranidium associated with that represented by fig. 14, × 3. U. S. Nat. Mus., Cat. No. 58067.

17. Type specimens showing portion of central parts of cephalon; and side outline of same, × 5. From Locality C 64, Upper Cambrian, Ch'au-mi-tién formation, southwest of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 58068.

Solenopleura agno Walcott (p. 167).

15. Type specimen showing portions of central parts of cephalon; and side outline of same, × 3. From Locality C 25, Middle Cambrian, Ch'ang-hia formation at Ch'ang-hia, Shan-tung. U. S. Nat. Mus., Cat. No. 58069.

Solenopleura intermedia (Walcott) (p. 169).

16. Small cephalon, showing scattered tubercles on the surface, × 3. From Locality C 51, Middle Cambrian, Ch'ang-hia limestone at Ch'au-mi-tién, Shan-tung. U. S. Nat. Mus., Cat. No. 58072.

16*a*. Associated free cheek, doubtfully referred to this species. U. S. Nat. Mus., Cat. No. 58073.

Description of Plate 17—Continued.

Solenopleura pauperata Walcott (p. 169).

18. Type specimen showing portions of central parts of cephalon; and side outline of same, × 5. From Locality C71, Middle Cambrian, Ki-chóu formation, southwest of Tung-yü, Shan-si. U. S. Nat. Mus., Cat. No. 58074.

Solenopleura sp. undt. Walcott (p. 170).

19. Pygidium doubtfully referred to this genus, × 4. From Locality C21, Middle Cambrian, Ch'ang-hia formation at Ch'ang-hia, Shan-tung. U. S. Nat. Mus., Cat. No. 58075.

Chuangia batia (Walcott) (p. 170).

20. Central parts of cephalon of a specimen from which the test has been exfoliated, from Locality C64, Upper Cambrian, Ch'au-mi-tién limestone, Kiu-lung group, southwest of Yen-chuang, Shan-tung. Natural size. U. S. Nat. Mus., Cat. No. 58062.

20*a*. Top view and side outline of a fragment of the central parts of a cephalon from Locality C44, Upper Cambrian, Ch'au-mi-tién limestone, at Ch'au-mi-tién, Shan-tung. Natural size. U. S. Nat. Mus., Cat. No. 57606.

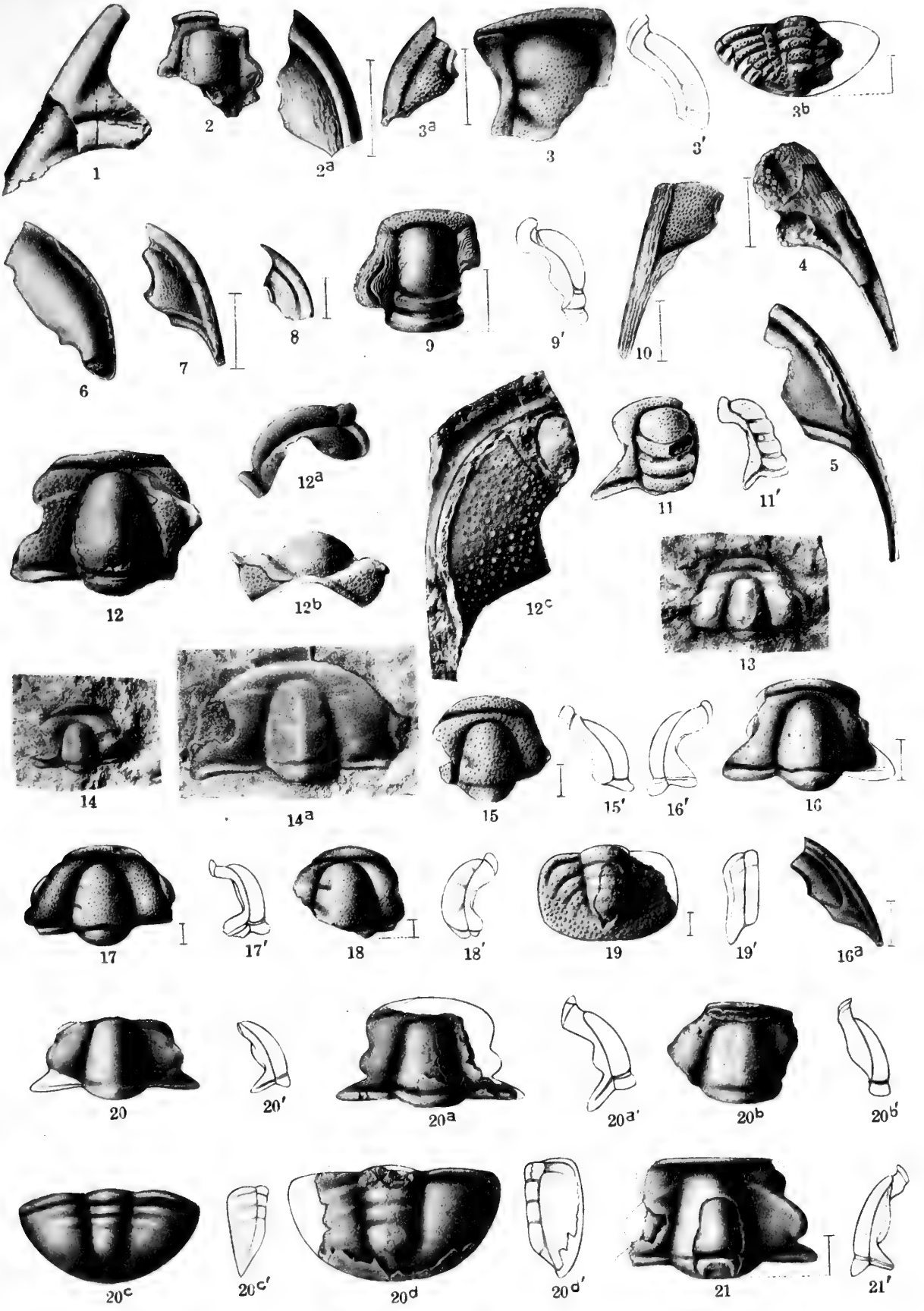
20*b*. Top view and side outline of a fragment of the central parts of a cephalon from Locality C33*a*, Upper Cambrian, Ch'au-mi-tién limestone, 9 miles (14.4 km.) north of Sin-t'ai-hién, Shan-tung. Natural size. U. S. Nat. Mus., Cat. No. 58063.

20*c*. Pygidium from Locality C11, Upper Cambrian, Ch'au-mi-tién limestone, 2.1 miles (3.4 km.) southwest of Yen-chuang, Shan-tung. Natural size. U. S. Nat. Mus., Cat. No. 58064.

20*d*. Cast of interior of a pygidium, associated with cephalon represented by fig. 20*a*. Natural size. From Locality C44, the same as 20*a*, Upper Cambrian, Ch'au-mi-tién limestone, at Ch'au-mi-tién, Shan-tung. U. S. Nat. Mus., Cat. No. 57576.

Chuangia nitida Walcott (p. 172).

21. Top view and side outline of a fragmentary specimen of central parts of a cephalon from the Ch'au-mi-tién limestone near Yen-chuang, × 3. From Locality C11, Upper Cambrian, southwest of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 57609.



COCKAYNE— BOSTON

Description of Plate 18.

Anomocare læve Angelin.

1. Dorsal view and side outline of cranidium, × 1.5. From Locality 8w, Middle Cambrian, *Paradoxides forchhammeri* beds, Andrarum, Sweden. U. S. Nat. Mus., Cat. No. 57592.

1*a*. Associated free cheek. (8w.) U. S. Nat. Mus., Cat. No. 57593.

1*b*. Associated pygidium. (8w.) U. S. Nat. Mus., Cat. No. 57594.

Anomocare latelimbatum Dames (p. 191).

2 and 2*a*. Dorsal views, natural size, of two type specimens of Dames now in the University Museum at Freiburg, Germany. [Fig. 2 = fig. 10, plate II; fig. 2*a* = fig. 16*a*, plate II, Dames, China, Richthofen, vol. IV, 1883.]

2*b*. Dorsal view and side outline of a cranidium. Natural size. From Locality 35n, Middle Cambrian, Fu-chóu series, Liau-tung, Manchuria. U. S. Nat. Mus., Cat. No. 58129.

2*c*. Dorsal view of associated pygidium and side outline. Natural size. From Locality 35n. U. S. Nat. Mus., Cat. No. 58130.

2*d*. Dorsal and side views of a specimen of cranidium. Natural size. From Locality C52, Middle Cambrian, Kiu-lung group, north-northeast of Sin-t'ai-hién, Shan-tung. U. S. Nat. Mus., Cat. No. 58131.

2*e*. Associated free cheek. (C52.) U. S. Nat. Mus., Cat. No. 58132.

Anomocare convexa Walcott (p. 187).

3. Dorsal shield and side outline. Natural size. U. S. Nat. Mus., Cat. No. 57595.

3*a*. Associated pygidium. U. S. Nat. Mus., Cat. No. 57596.

3*b*. Cephalon with posterior margin restored from fig. 3. U. S. Nat. Mus., Cat. No. 57597.

3*c*. Side outline of specimen represented by fig. 3*b*.

All the specimens represented are from locality 90x, Middle Cambrian, Conasauga formation, near Center, Alabama.

Anomocare lisani Walcott (p. 191).

4. Portions of a cranidium preserving the convexity, × 2. U. S. Nat. Mus., Cat. No. 57579.

4*a*. A cranidium flattened in the shale. Natural size. U. S. Nat. Mus., Cat. No. 57580.

4*b*. Associated free cheek. Natural size. U. S. Nat. Mus., Cat. No. 58133.

4*c*. Matrix of an associated pygidium. Natural size. U. S. Nat. Mus., Cat. No. 58134.

4*d*. Associated pygidium, × 2. U. S. Nat. Mus., Cat. No. 57581.

4*e*. Portion of a thoracic segment, × 2. U. S. Nat. Mus., Cat. No. 58135.

All of the specimens illustrated by figs. 4, 4*a–e* are from a layer of shale at Locality 35q, Middle Cambrian, Fu-chóu series, Liau-tung, Manchuria.

Anomocare ephori Walcott (p. 190).

5. Dorsal view of cranidium and side outline, × 2. U. S. Nat. Mus., Cat. No. 57577.

5*a*. Broken cranidium. Natural size. U. S. Nat. Mus., Cat. No. 58136.

5*b*. Associated pygidium, × 2. U. S. Nat. Mus., Cat. No. 57578.

The three specimens illustrated are from Locality 35r, Middle Cambrian, Fu-chóu series, Liau-tung, Manchuria.

Anomocare alcinoe Walcott (p. 187).

6. Dorsal and side views of type specimen, showing the central parts of the cephalon. Natural size. From Locality C57, Middle Cambrian, Kiu-lung group, north of Sin-t'ai-hién, Shan-tung. U. S. Nat. Mus., Cat. No. 58137.

6*a*. Associated free cheek. Natural size. U. S. Nat. Mus., Cat. No. 58138.

6*b*. Dorsal and side views of associated pygidium. Natural size. U. S. Nat. Mus., Cat. No. 58139.

Anomocare daulis Walcott (p. 189).

7. Dorsal view and side outline of type specimen, showing cephalon, × 1.5. From Locality C19, Middle Cambrian, Ch'ang-hia limestone, Ch'ang-hia, Shan-tung. U. S. Nat. Mus., Cat. No. 58140.

7*a*. Fragment of a pygidium associated with the specimen represented by fig. 1. U. S. Nat. Mus., Cat. No. 58141.

Anomocare flava Walcott (p. 190).

8. Fragmentary specimen of central parts of cephalon, and side outline of same, × 2.5. U. S. Nat. Mus., Cat. No. 58143.

8*a*. Associated free cheek, × 2.5. U. S. Nat. Mus., Cat. No. 58144.

8*b*. Fragmentary specimen of central parts of a cephalon associated with specimen represented by fig. 8, × 1.5. U. S. Nat. Mus., Cat. No. 58145.

8*c*. Associated pygidium, × 2. U. S. Nat. Mus., Cat. No. 58146.

The four specimens illustrated are from Locality C72, Middle Cambrian, Ki-chóu formation, east of Fang-lan-chön, Shan-si.

Anomocare megalurus (Dames) (p. 192).

9. Dorsal and side views of small cranidium, × 2. U. S. Nat. Mus., Cat. No. 58147.

9*a*. Dorsal and side views of portion of a large cranidium, × 1.5. U. S. Nat. Mus., Cat. No. 58148.

9*b*. Associated free cheek, × 3. U. S. Nat. Mus., Cat. No. 58149.

9*c*. Associated hypostoma, × 4. U. S. Nat. Mus., Cat. No. 58150.

9*d*. Associated pygidium and side view, × 1.5. U. S. Nat. Mus., Cat. No. 58151.

The specimens represented by figs. 9, 9*a–d* are from Locality C37, Upper Cambrian, Ki-chóu limestone, south of Ting-hiang-hién, Shan-si.

9*e*. Dorsal view and side outline of a cranidium, × 2. From Locality 35n, Middle Cambrian, Fu-chóu series, Liau-tung, Manchuria. U. S. Nat. Mus., Cat. No. 58152.

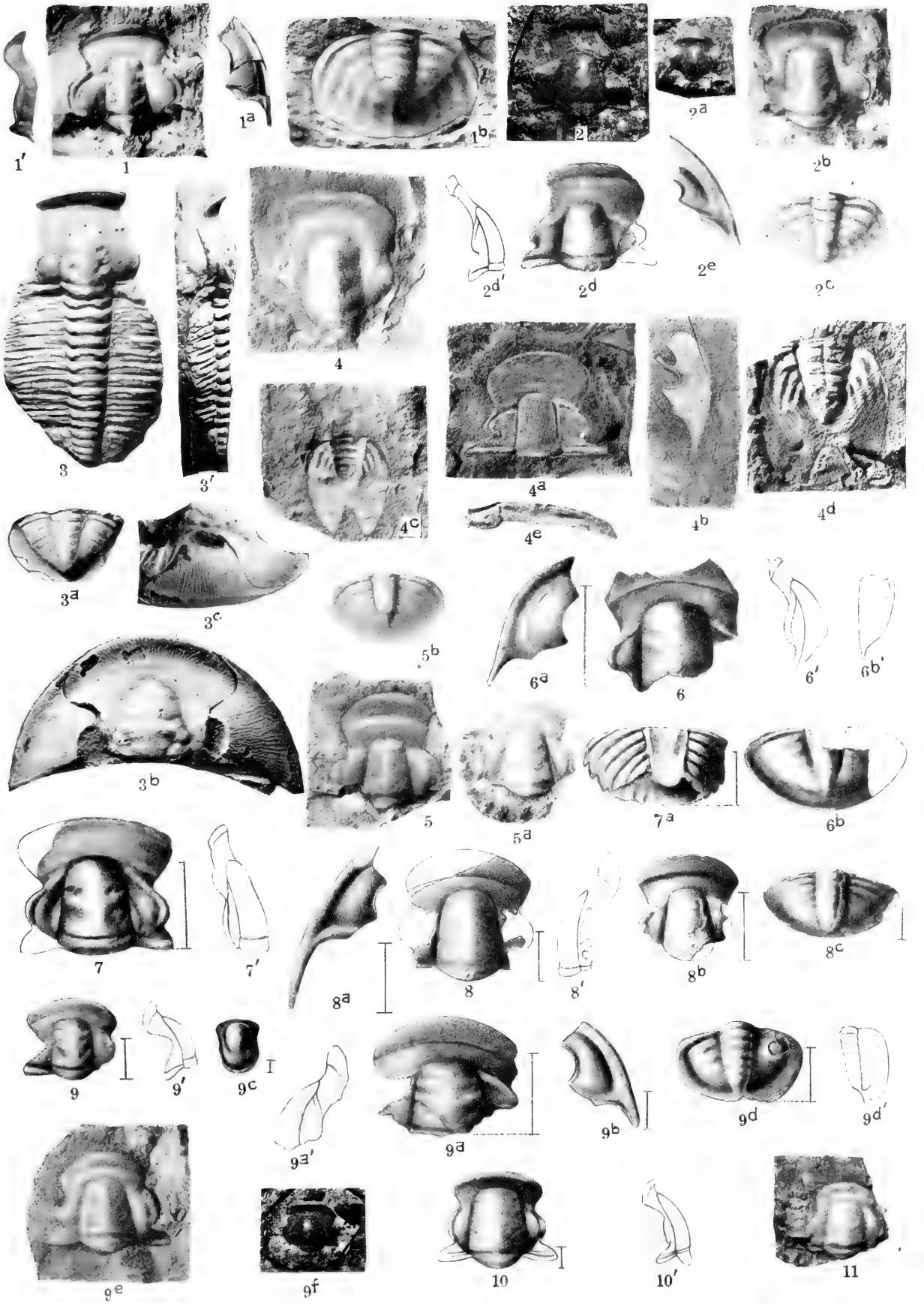
9*f*. Reproduction of photograph of type specimen of Dames. Natural size. Now in collection of University Museum at Freiburg, Germany, and supposed original of fig. 7, plate I, vol. IV, Dames, Richthofen, China, 1883.

Anomocare ? nereis (Walcott) (p. 193).

10. Dorsal view and side outline of type specimen, a small cranidium, × 4. From Locality C69, Middle Cambrian, Ki-chóu limestone, east of Fang-lan-chön, Shan-si. U. S. Nat. Mus., Cat. No. 58153.

Anomocare subquadratum (Dames) (p. 194).

11. Dorsal view and side outline of a cranidium. Natural size. From Locality 35n, Middle Cambrian, Fu-chóu series limestone, Liau-tung, Manchuria. U. S. Nat. Mus., Cat. No. 58155.



COCKAYNE—BOSTON

Description of Plate 19.

Anomocare minus Dames (p. 192).

1. Dorsal view and side outline of a cranidium, × 1.5. From Locality C 9, Middle Cambrian, Kiu-lung group, southwest of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 58156.

1*a*. Dorsal view and side outline of cranidium, × 2. From Locality 35 n, Middle Cambrian, Fu-chóu series, Liau-tung, Manchuria. U. S. Nat. Mus., Cat. No. 58157.

1*b*. Free cheek, × 2. From Locality 35 n the same as fig. 1*a*. U. S. Nat. Mus., Cat. No. 58158.

1*c*. Portion of a dorsal shield flattened in shale, showing axial lobe, part of pleural lobes of thorax, and pygidium. Natural size. U. S. Nat. Mus., Cat. No. 58159.

1*d*. Right side of a dorsal shield flattened in shale. Natural size. U. S. Nat. Mus., Cat. No. 58160.

The two specimens of figs. 1*c* and 1*d* are from Locality 36 e, Middle Cambrian, Fu-chóu series, shales interbedded in limestones, Liau-tung, Manchuria.

Anomocare minus var. Walcott.

2. Dorsal view and side outline of a cranidium, × 2. From Locality 35 n, Middle Cambrian, Fu-chóu series limestone, Liau-tung, Manchuria. U. S. Nat. Mus., Cat. No. 58161.

2*a*. × 2 Pygidium occurring in same layer of limestone with typical forms of the cranidia of the species. U. S. Nat. Mus., Cat. No. 58162.

Anomocare sp. undt. (*c*) **Walcott** (p. 194).

3 and 3*a*. Free cheek and pygidium from Locality C 46, Middle Cambrian, Ch'ang-hia limestone at Ch'au-mi-tién, Shan-tung. U. S. Nat. Mus., Cat. Nos. 58163 and 58164.

Anomocare sp. undt. (*a*) **Walcott** (p. 194).

4. Pygidium from Locality C 64, Upper Cambrian, Kiu-lung group limestone, 2.7 miles (4.3 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung. U. S. Nat. Mus., Cat. No. 58165.

Anomocare sp. undt. (*b*) **Walcott** (p. 194).

5. Pygidium from Locality C 5, Middle Cambrian, Kiu-lung group, 3.2 miles (5.1 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung. U. S. Nat. Mus., Cat. No. 58166.

Anomocare ? sp. undt. (*d*) **Walcott** (p. 194).

6. Fragment of pygidium doubtfully referred to this genus. From Locality C 30, Middle Cambrian, Ch'ang-hia limestone at Ch'ang-hia, Shan-tung. U. S. Nat. Mus., Cat. No. 58167.

Anomocarella butes Walcott (p. 199).

7. Dorsal view and side outline of a cephalon. Natural size. From Locality C 52, Middle Cambrian, Kiu-lung group, north-northeast of Sin-t'ai-hién, Shan-tung. U. S. Nat. Mus., Cat. No. 58168.

7*a*. Central parts and side outline of cranidium. Natural size. U. S. Nat. Mus., Cat. No. 58169.

7*b*. Associated free cheek, × 3. U. S. Nat. Mus., Cat. No. 58170.

7*c*. Portion of a cranidium, × 1.5. U. S. Nat. Mus., Cat. No. 58171.

7*d*. Pygidium referred to this species, × 1.5. U. S. Nat. Mus., Cat. No. 58172.

The specimens illustrated by figs. 7*a–d* are from Locality C 5, Middle Cambrian, Kiu-lung group, southwest of Yen-chuang, Shan-tung.

Anomocarella irma Walcott (p. 202).

8. Type specimen, showing the cranidium and side view of same, × 4. U. S. Nat. Mus., Cat. No. 58173.

8*a*. Pygidium associated with specimen represented by fig. 8, × 4. From Locality C 77, Middle Cambrian, limestone interbedded in green shales, southeast of Yau-t'o, near Wu-t'ai-hién, Shan-si. U. S. Nat. Mus., Cat. No. 58174.

Anomocarella comus (Walcott) (p. 201).

9. Type specimen of cranidium, × 3. From Locality C 71, Middle Cambrian, Ki-chóu formation, southwest of Tung-yü, Shan-si. U. S. Nat. Mus., Cat. No. 58175.

9*a*. Associated pygidium, × 3. U. S. Nat. Mus., Cat. No. 58176.

Anomocarella toxeus (Walcott) (p. 208).

10. Dorsal and side views of type specimen of cranidium, × 3. From Locality C 27, Middle Cambrian, Ch'ang-hia limestone, east-southeast of Ch'ang-hia, Shan-tung. U. S. Nat. Mus., Cat. No. 58177.

10*a*. Top and side views of associated pygidium. U. S. Nat. Mus., Cat. No. 58178.

Anomocarella trogus (Walcott) (p. 209).

11. Dorsal and side views of type specimen of the cranidium, × 4. From Locality C 25, Middle Cambrian, Ch'ang-hia formation, at Ch'ang-hia, Shan-tung. U. S. Nat. Mus., Cat. No. 58179.

Anomocarella subrugosa (Walcott) (p. 205).

12. Dorsal and side views of type specimen of the cranidium, × 3. From Locality C 7, Middle Cambrian, Kiu-lung group, southwest of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 58180.

Anomocarella bergioni Walcott (p. 197).

13. Dorsal and side views of type specimen, showing central parts of cranidium, × 2. From Locality C 33*a*, Upper Cambrian, Ch'au-mi-tién limestone, north of Sin-t'ai-hién, Shan-tung. U. S. Nat. Mus., Cat. No. 58181.

13*a*. Associated free cheek. Natural size. U. S. Nat. Mus., Cat. No. 58182.

Anomocarella thraso (Walcott) (p. 208).

14. Dorsal view and side outline of type specimen of the cranidium, × 2. From Locality C 7, Middle Cambrian, Kiu-lung group, southwest of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 58183. This specimen is on a fragment of limestone with *Inouyia titiana* (plate 14, fig. 9).

14*a*. Associated pygidium. U. S. Nat. Mus., Cat. No. 58184.

Anomocarella tutia (Walcott) (p. 209).

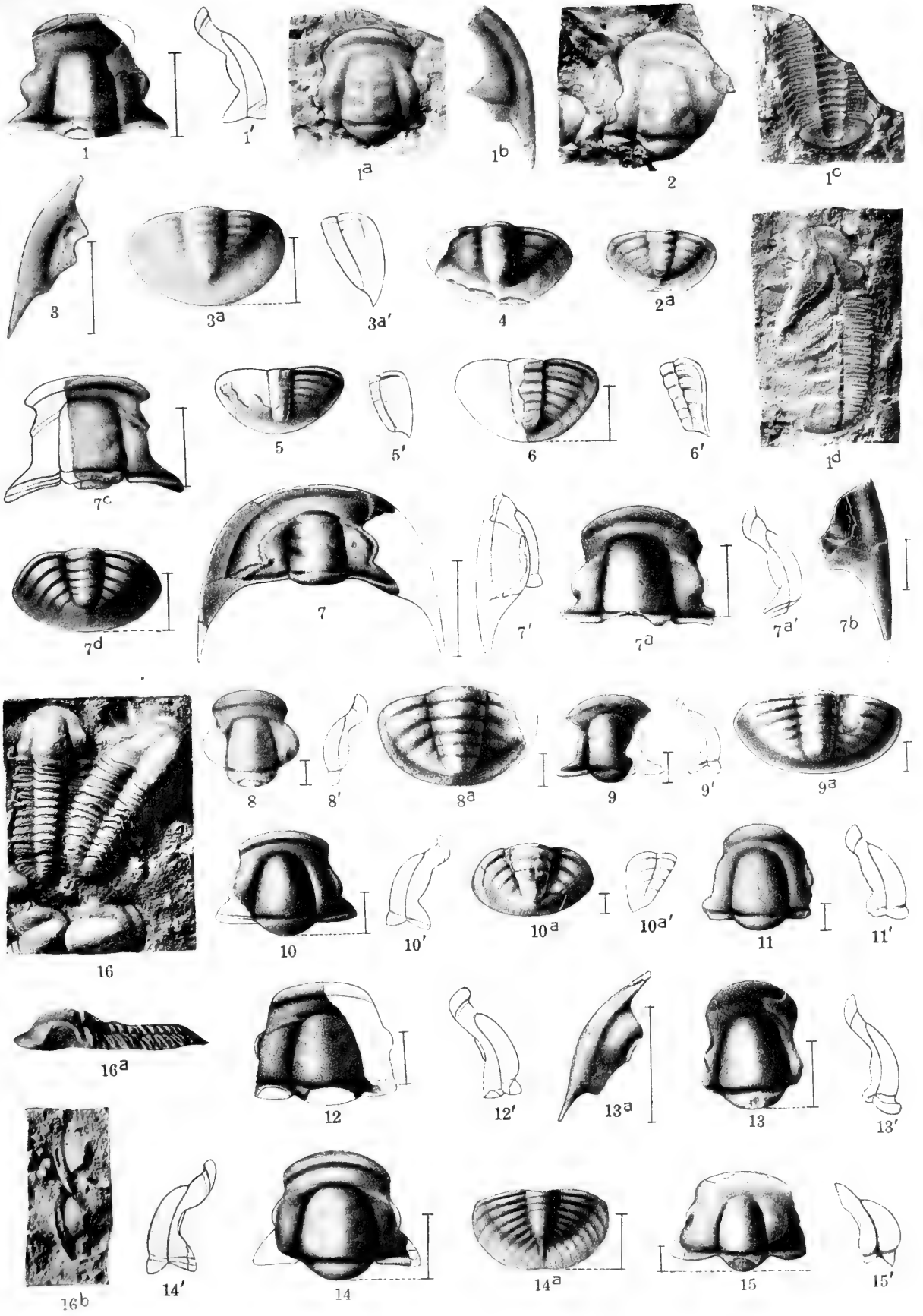
15. Dorsal view and side outline of type specimen of the cranidium, × 4. From Locality C 12, Middle Cambrian, Kiu-lung group, southwest of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 58185.

Anomocarella smithi Walcott (p. 203).

16. Photograph of a portion of a flat siliceous nodule on which several specimens of nearly entire dorsal shields occur, × 2. From Locality 90 x, Middle Cambrian, Conasauga shale, Coosa Valley, Alabama. U. S. Nat. Mus., Cat. No. 57598.

16*a*. Side view of dorsal shield on the right in fig. 16.

16*b*. Associated free cheeks, × 2. U. S. Nat. Mus., Cat. No. 58296.



COCKAYNE—BOSTON

Description of Plate 20.

Anomocarella albion Walcott (p. 195).

1. Dorsal view and side outline of type specimen of cephalon. Natural size. From Locality C57, the Kiu-lung group, 3 miles (4.8 km.) south of Kao-kia-p'u, Sin-t'ai district, Shan-tung. U. S. Nat. Mus., Cat. No. 58186.

1*a*. Free cheek associated with fig. 1*b*. Natural size. U. S. Nat. Mus., Cat. No. 58187.

1*b*. Dorsal view of a compressed fragment of central parts of cephalon, × 2. From Locality C2, Middle Cambrian, Kiu-lung group, south of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 58188.

1*c*. Hypostoma associated with figs. 1*a*, 1*b*, and 1*d*, × 1.5. U. S. Nat. Mus., Cat. No. 58189.

1*d*. Pygidium associated with fig. 1*b*. Natural size. U. S. Nat. Mus., Cat. No. 58190.

1*e*. Pygidium, × 2, from same horizon as the specimen represented by fig. 1; Locality C4, 3 miles (4.8 km.) southwest of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 58191.

1*f*. Fragmentary pygidium, × 2, associated with this species from Locality C1, Kiu-lung group, south of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 58192.

Anomocarella baucis Walcott (p. 196).

2. Fragment of central parts of cephalon, × 1.5. From Locality C36, Upper Cambrian, Ch'au-mi-tién limestone at Ch'au-mi-tién, Shan-tung. U. S. Nat. Mus., Cat. No. 58193.

2*a*. Associated pygidium referred to this species. Natural size. U. S. Nat. Mus., Cat. No. 58194.

Anomocarella chinensis Walcott (p. 200).

3. Typical form of central parts of cephlon; with side outline, × 2. (C62.) U. S. Nat. Mus., Cat. No. 58203.

3*a*. Associated free cheek, × 2. (C62.) U. S. Nat. Mus., Cat. No. 58204.

3*b*. Central parts of cephalon, in which frontal border does not curve backward at center, × 1.5. (C57.) U. S. Nat. Mus., Cat. No. 58207.

3*c*. Central parts of cephalon, × 1.5 (C2), differing in the frontal border and rim, also in the glabella, from the specimens represented by figs. 3 and 3*b*. U. S. Nat. Mus., Cat. No. 58208.

3*d* (× 2.5) and 3*e* (× 3). Pygidia associated with the cephalon represented by fig. 3. U. S. Nat. Mus., Cat. Nos. 58205 and 58206.

Figures 3, 3*a*, and 3*d–e* represent specimens from Locality C62, Middle Cambrian, Kiu-lung group, 2.5 miles (4 km.) south of Yen-chuang, Sin-t'ai district, Shan-tung.

The specimen represented by fig. 3*b* is from Locality C57, 3 miles (4.8 km.) south of Kao-kia-p'u, and the specimen represented by fig. 3*c* is from Locality C2, 2 miles (3.2 km.) south of Yen-chuang.

4. Cranidium in limestone, × 2. From Locality 35n, Middle Cambrian, Fu-chóu series, Liau-tung, Manchuria. U. S. Nat. Mus., Cat. No. 58209.

4*a*. Entire dorsal shield flattened in argillaceous shale, × 3. From Locality 36g, Fu-chóu series, about 130 feet (39.6 m.) above specimen represented by fig. 4. U. S. Nat. Mus., Cat. No. 58210.

Anomocarella hermias Walcott (p. 202).

5. A cranidium and side outline, × 4. From Locality 35n, Middle Cambrian, Fu-chóu series, Liau-tung, Manchuria. U. S. Nat. Mus., Cat. No. 58195.

5*a*. A cranidium, type specimen, associated with that represented by fig. 5, × 4. U. S. Nat. Mus., Cat. No. 57582.

Anomocarella macar Walcott (p. 203).

6. A small cranidium and side outline, × 3. U. S. Nat. Mus., Cat. No. 57584.

6*a*. A large, broken cranidium and side outline. Natural size. U. S. Nat. Mus., Cat. No. 57583.

6*b*. Associated free cheek, × 1.5. U. S. Nat. Mus., Cat. No. 58197.

6*c*. Associated pygidium. Natural size. U. S. Nat. Mus., Cat. No. 58196.

6*d*. Associated pygidium, × 1.5. U. S. Nat. Mus., Cat. No. 57585.

The specimens illustrated by figs. 6 and 6*a–d* are in limestone from Locality 35n, Middle Cambrian, Fu-chóu series, Liau-tung, Manchuria.

Anomocarella temenus (Walcott) (p. 206).

7. The type specimen, showing principal parts of cranidium, × 1.5. U. S. Nat. Mus., Cat. No. 58214.

7*a*. Associated free cheek, × 1.5. U. S. Nat. Mus., Cat. No. 58215.

7*b*. Associated free cheek, × 1.5. U. S. Nat. Mus., Cat. No. 58216.

7*c*. Fragmentary specimen of a cranidium, × 1.5. U. S. Nat. Mus., Cat. No. 58217.

7*d*. Associated pygidium, × 2. U. S. Nat. Mus., Cat. No. 58218.

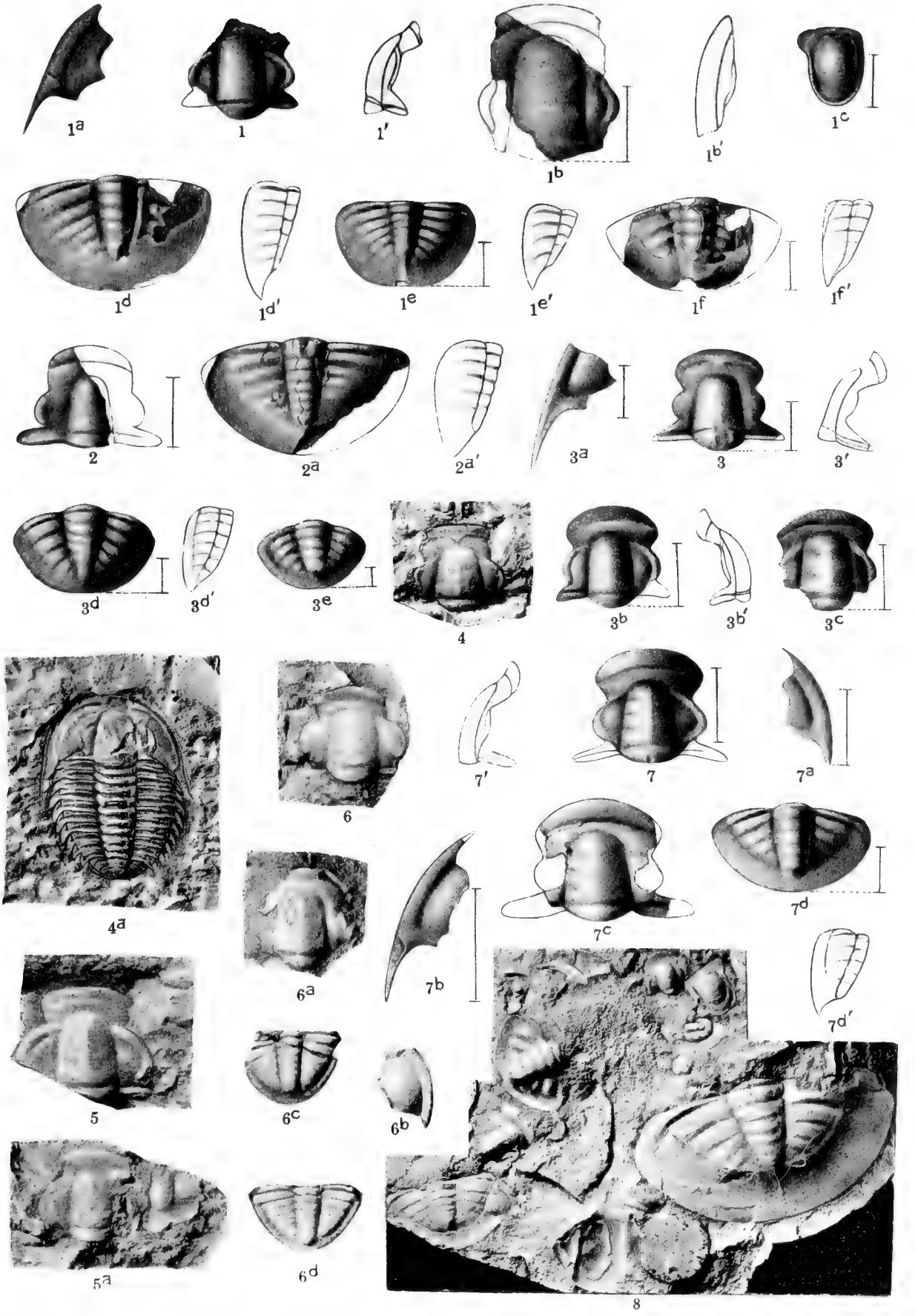
The specimens illustrated are from Locality C10, Middle Cambrian, Kiu-lung group, southwest of Yen-chuang, Shan-tung.

Anomocarella speciosa (Lorenz) (p. 205).

8. Photograph (× 1.33) of one of the fragments of limestone collected by Dr. Th. Lorenz at Wang-tschuang, Shan-tung.

Two specimens of cranidium are shown—one near upper margin and one on left side between the two pygidia. The pygidium at the lower left side may be referred to this species. The pygidium above on the left side is that of *Dolichometopus deois* Walcott. [See plate 22.] The hypostoma near the top and the large pygidium on the right are referred by Lorenz on the label accompanying the specimen to *Anomocare* sp.

Three of the specimens are illustrated by Lorenz. [Lorenz, 1906, plate v, figs. 6, 7, and 12.] U. S. Nat. Mus., Cat. No. 58540.



COCKAYNE—BOSTON

Description of Plate 21.

Anomocarella tatian (Walcott) (p. 206).

1. Dorsal and side views of type specimen of cranidium, × 1.5. From Locality C23, Middle Cambrian, east-southeast of Ch'ang-hia, Shan-tung. U. S. Nat. Mus., Cat. No. 58198.

1*a*. Associated free cheek, × 1.5. (C23.) U. S. Nat. Mus., Cat. No. 58199.

1*b*. Associated pygidium × 1.5. (C23.) U. S. Nat. Mus., Cat. No. 58200.

Anomocarella biston (Walcott) (p. 198).

2. Type specimen of cranidium of this species, and side outline, × 3. From Locality C2, Middle Cambrian, Kiu-lung group, south of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 58201.

Anomocarella bigsbyi (Walcott) (p. 198).

3. Cranidium with smooth glabella, × 2.5. U. S. Nat. Mus., Cat. No. 58219.

3*a*. Cranidium and side outline, × 1.5. U. S. Nat. Mus., Cat. No. 58220.

3*b*. Associated pygidium referred to this species, × 2. U. S. Nat. Mus., Cat. No. 58221.

The three specimens illustrated are from Locality C71, Middle Cambrian, Ki-chóu formation, south of Tung-yü, Shan-si.

Anomocarella tenes (Walcott) (p. 207).

4. Cranidium and side outline view of type specimen, × 4. From Locality C28, Middle Cambrian, Ch'ang-hia limestone, east-southeast of Ch'ang-hia, Shan-tung. U. S. Nat. Mus., Cat. No. 58222.

Anomocarella undata (Walcott) (p. 210).

5. Cranidium and side outline of type specimen, × 4. From Locality C71, Middle Cambrian, Ki-chóu formation, southwest of Tung-yü, Shan-si. U. S. Nat. Mus., Cat. No. 58202.

Coosia superba Walcott (p. 213).

6. A nearly entire dorsal shield, with exception of free cheeks of cephalon. Natural size. From Locality 91, Middle Cambrian, Conasauga formation, Coosa River at Cedar Bluff, Alabama. U. S. Nat. Mus., Cat. No. 57589.

6*a*. Side view of specimen represented by fig. 6. U. S. Nat. Mus., Cat. No. 57589.

Coosia carme (Walcott) (p. 211).

7. Dorsal view and side outline of type specimen of cranidium, × 1.5. From Locality C38, Upper Cambrian, Ch'au-mi-tién limestone at Ch'au-mi-tién, Shan-tung. U. S. Nat. Mus., Cat. No. 58226.

Coosia decelus (Walcott) (p. 212).

8. Dorsal view and side outline of type specimen, showing cranidium. Natural size. From Locality C9, Middle Cambrian, Kiu-lung group, southwest of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 58227.

Coosia robusta Walcott (p. 213).

9. Dorsal and side views of type specimen of cranidium. Natural size. From Locality 107, Middle Cambrian, Rome formation limestone at Bull Run, Copper Ridge, northwest of Knoxville, Tennessee. U. S. Nat. Mus., Cat. No. 57590.

9*a*. Associated pygidia, × 2. U. S. Nat. Mus., Cat. No. 57591.

Coosia ? bianos (Walcott) (p. 210).

10. Dorsal view and side outline of type specimen of cranidium. Natural size. From Locality C64, Upper Cambrian, Kiu-lung group, southwest of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 58228.

10*a*. Associated pygidium with broad border broken away. U. S. Nat. Mus., Cat. No. 58229.

Coosia ? daunus (Walcott) (p. 211).

11. Fragment of a cranidium, showing glabella and a portion of frontal limb. Natural size. U. S. Nat. Mus., Cat. No. 58230.

11*a*. Fragment of a free cheek associated with specimen represented by fig. 11. Natural size. U. S. Nat. Mus., Cat. No. 58231.

11*b*. Pygidium associated with specimens represented by figs. 11 and 11*a*. Natural size. U. S. Nat. Mus., Cat. No. 58232.

11*c*. Enlargement to show the peculiar, punctate outer surface.

All of the specimens illustrated are from Locality C2, Middle Cambrian, Kiu-lung group, south of Yen-chuang, Shan-tung.

Coosia (?) limbata (Angelin) (p. 214).

12. Cranidium somewhat flattened in limestone matrix. Natural size. From Locality 8w, Middle Cambrian, Andrarum limestone, Andrarum, Sweden. U. S. Nat. Mus., Cat. No. 58233.

12*a*. Associated pygidium. U. S. Nat. Mus., Cat. No. 58234.

Dolichometopus deois Walcott [see plate 22] (p. 216).

13. Cranidium curled down and flattened in shale, × 2. U. S. Nat. Mus., Cat. No. 58235.

13*a*. Matrix of a cranidium flattened in shale, × 2. U. S. Nat. Mus., Cat. No. 58236.

13*b*. Free cheek associated with figs. 13 and 13*a*, × 2. U. S. Nat. Mus., Cat. No. 58237.

13*c*. Matrix of a pygidium associated with fig. 13*a*, × 2. U. S. Nat. Mus., Cat. No. 58238.

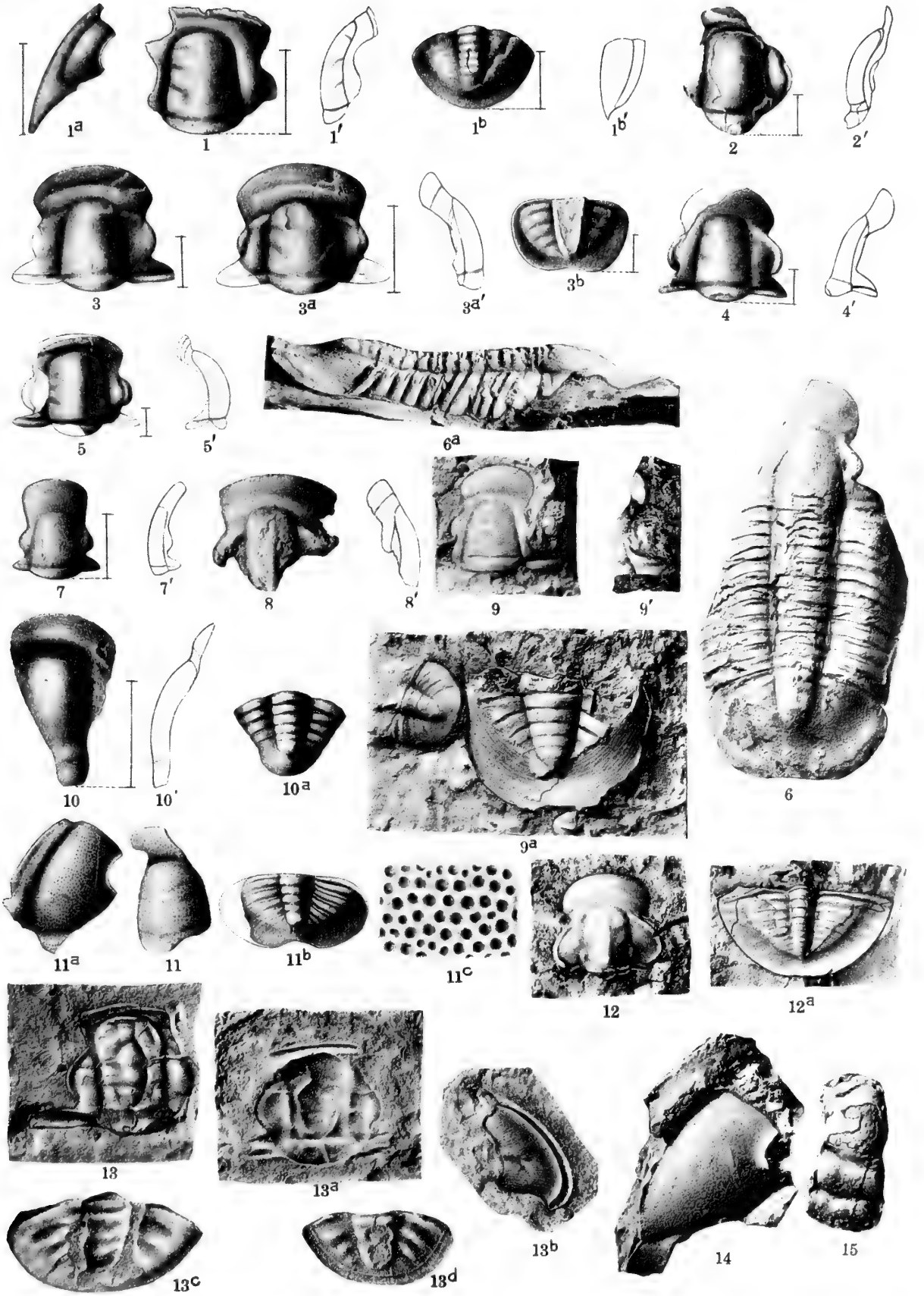
13*d*. Pygidium with test removed, × 2. U. S. Nat. Mus., Cat. No. 58239.

All of the specimens represented by figs. 13, 13*a–d* are in argillaceous shale from Locality 350, Middle Cambrian, Fu-chóu series, Liau-tung, Manchuria.

Ptychaspis ? spp. undt. Walcott [see plate 17, figs. 1, 6–8] (p. 186).

14. A large free cheek. Natural size. From Locality C64, Upper Cambrian, upper limestone of Kiu-lung group, southwest of Yen-chuang, Shan-tung, China. U. S. Nat. Mus., Cat. No. 58127.

15. Portion of a large glabella. Natural size. From Locality C54, Upper Cambrian, Ch'au-mi-tién limestone, west of Tsi-nan, Shan-tung, China. U. S. Nat. Mus., Cat. No. 58128.



COCKAYNE—BOSTON

Description of Plate 22.

Dolichometopus deois Walcott [see plate 21, figs. 13, 13*a–d*] (p. 216).

1. Dorsal view and side outline of a cranidium, × 2, from Locality **C 1**, Middle Cambrian, Kiu-lung group, 2 miles (3.2 km.) south of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 58240.

1*a*. Free cheek, × 3, associated with fig. 1*b*. U. S. Nat. Mus., Cat. No. 58241.

1*b*. Dorsal view and side outline of a cranidium, × 2. (**C 57**.) U. S. Nat. Mus., Cat. No. 58242.

1*c*. Hypostoma, × 3, associated with the specimen represented by fig. 1*b*. (**C 57**.) U. S. Nat. Mus., Cat. No. 58243.

1*d* and 1*e*. Nepionic stages, × 15, in the development of a trilobite, probably of this species. (**C 57**.) U. S. Nat. Mus., Cat. Nos. 58244 and 58245.

1*f*. A cranidium (× 10) of a young individual associated with specimen represented by fig. 1*b*. (**C 57**.) U. S. Nat. Mus., Cat. No. 58246.

1*g*. Thoracic segment, × 3, associated with specimen represented by fig. 1*b*. (**C 57**.) U. S. Nat. Mus., Cat. No. 58247.

The specimens represented by figs. 1*a–g* are from Locality **C 57**, Middle Cambrian, Kiu-lung group, south of Kao-kia-p'u, Shan-tung.

1*h*. Pygidium, natural size, from Locality **C 4**, a little below the layer from which specimen represented by fig. 1 was collected. U. S. Nat. Mus., Cat. No. 58248.

2. Photograph (× 1.5) of one of the fragments of limestone collected by Dr. Th. Lorenz at Wang-tschuang, Shan-tung. The pygidia were referred to *Bathyuriscus asiaticus* Lorenz, by Lorenz, and the cranidia on the other side of the same piece of limestone to the same species. [Lorenz, 1906, plate v, figs. 1–5.] U. S. Nat. Mus., Cat. No. 58538.

2*a* and 2*b*. Cranidia on the opposite side of the piece of limestone illustrated by fig. 2. U. S. Nat. Mus., Cat. No. 58539.

Dolichometopus alceste Walcott (p. 215).

3. Type specimen showing parts of cranidium in front of occipital furrow; with side outline of same, × 2. From Locality **C 4**, Middle Cambrian, Kiu-lung group, south of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 58249.

3*a*. Free cheek associated with this species at Locality **C 4**. U. S. Nat. Mus., Cat. No. 58250.

3*b*. Pygidium associated with this species a little lower in the section (**C 1**). U. S. Nat. Mus., Cat. No. 58251.

Dolichometopus derceto Walcott (p. 217).

4. Type specimen showing portions of the cranidium; and side outline of same, × 3. From Locality **C 1**, Middle Cambrian, Kiu-lung group, south of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 58252.

4*a*. Fragment of a pygidium from **C 2**, just above the locality of specimen represented by fig. 4. U. S. Nat. Mus., Cat. No. 58253.

Dolichometopus dirce Walcott (p. 218).

5. Type specimen showing central parts of cranidium; and side outline of same, × 2. From Locality **C 24**, Middle Cambrian, Ch'ang-hia formation, east of Ch'ang-hia, Shan-tung. U. S. Nat. Mus., Cat. No. 58254.

5*a*. Large free cheek (natural size) associated with specimen represented by fig. 5. U. S. Nat. Mus., Cat. No. 58255.

5*b*. Small pygidium associated with specimen represented by fig. 5, × 4. U. S. Nat. Mus., Cat. No. 58256.

Dolichometopus hyrie Walcott (p. 218).

6. Type specimen showing central parts of cranidium; and side outline of same, × 3. From Locality **C 69**, Middle Cambrian, Ki-chóu limestone east of Fang-lan-chön, Shan-si. U. S. Nat. Mus., Cat. No. 58257.

6*a*. Associated free cheek, × 2. U. S. Nat. Mus., Cat. No. 58258.

6*b*. Associated pygidium. Natural size. U. S. Nat. Mus., Cat. No. 58259.

Bathyuriscus ? sp. undt. Walcott.

7. A small, smooth pygidium from Locality **C 28**, Middle Cambrian, base of the Ch'ang-hia limestone, 1 mile (1.6 km.) east-southeast of Ch'ang-hia, Shan-tung. U. S. Nat. Mus., Cat. No. 58264.

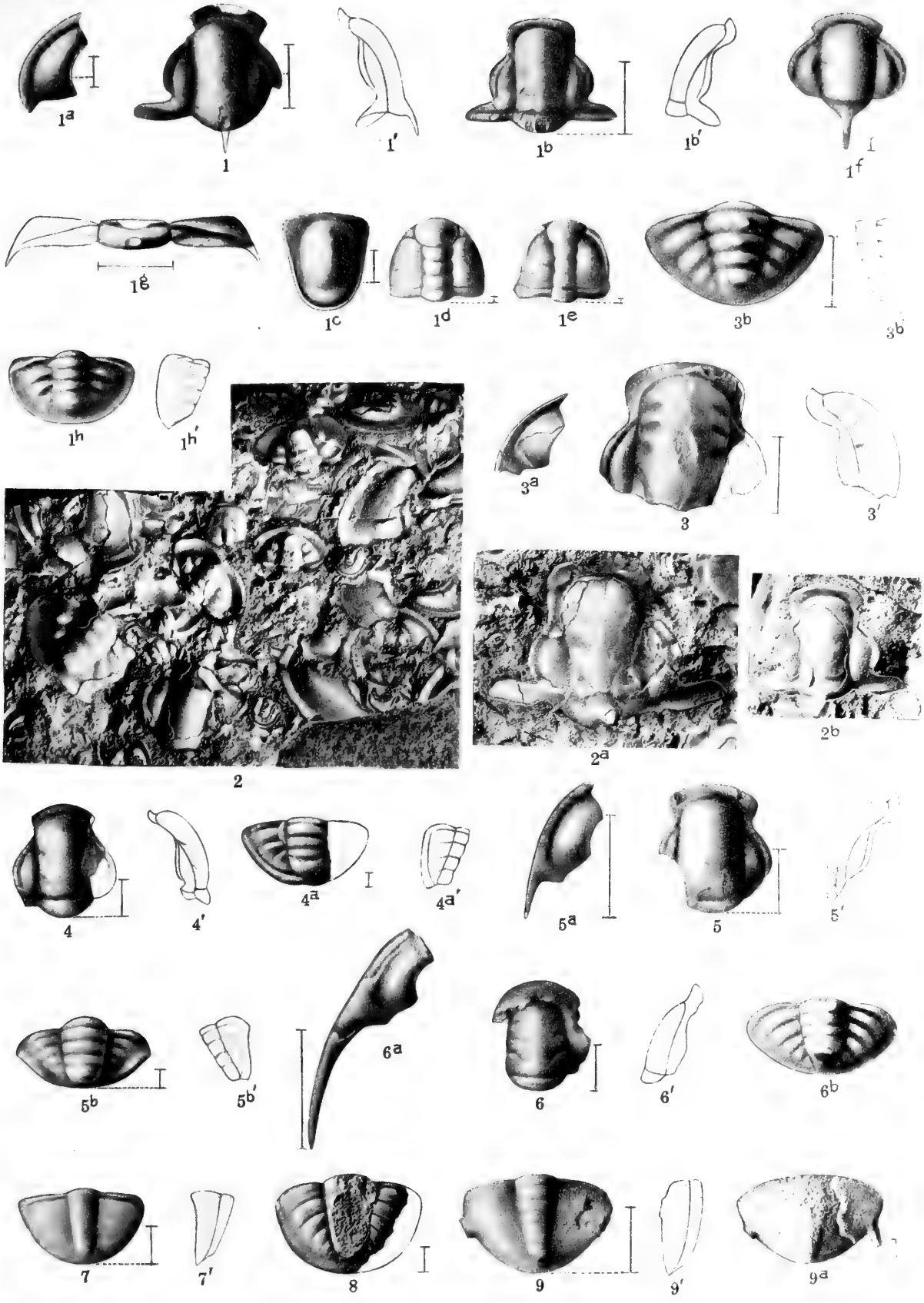
Bathyuriscus ? ? sp. undt. Walcott.

8. Small pygidium from Locality **C 68**, Upper Cambrian, Ch'au-mi-tién limestone near Ch'au-mi-tién, Shan-tung. U. S. Nat. Mus., Cat. No. 58265.

Hysterolenus ? spp. undt. Walcott [see plate 23, fig. 9] (p. 219).

9. Dorsal and side views of a large specimen of pygidium. From Locality **C 38**, Upper Cambrian, Ch'au-mi-tién limestone, at Ch'au-mi-tién, Shan-tung. U. S. Nat. Mus., Cat. No. 58266.

9*a*. Dorsal view of small pygidium, × 4. From Locality **C 56**, Upper Cambrian, Ch'au-mi-tién limestone west of Tsi-nan, Shan-tung. U. S. Nat. Mus., Cat. No. 58267.



COCKAYNE BOSTON

Description of Plate 23.

Asaphiscus iddingsi Walcott (p. 221).

1. Dorsal shield, flattened in argillaceous shale, × 2. From Locality 36e, Middle Cambrian, Fu-chóu series, shale interbedded in limestone, Liau-tung, Manchuria. U. S. Nat. Mus., Cat. No. 57586.

1*a*. Cranidium, × 2, from limestone associated with the shale mentioned under fig. 1. (35r.) U. S. Nat. Mus., Cat. No. 58269.

1*b*. A smaller cranidium, × 3, associated with the specimen represented by fig. 1*a*. U. S. Nat. Mus., Cat. No. 58270.

Bathyuriscus manchuriensis Walcott (p. 219).

2. Fragment of shale with three cranidia flattened in it, × 3. U. S. Nat. Mus., Cat. No. 57587.

2*a*. Associated free cheek, × 3. U. S. Nat. Mus., Cat. No. 58271.

2*b*. Associated thoracic segment, × 3. U. S. Nat. Mus., Cat. No. 58272.

2*c*. Associated pygidium, × 3. U. S. Nat. Mus., Cat. No. 58273.

2*d*. Associated minute cranidium, × 8. On shale with specimens represented by fig. 2. U. S. Nat. Mus., Cat. No. 57587.

2*e* and 2*f*. Associated hypostomas, × 4. U. S. Nat. Mus., Cat. Nos. 58275 and 58276.

All of the specimens illustrated are from Locality 36h, Middle Cambrian, Fu-chóu series, argillaceous, shales, Liau-tung, Manchuria.

Illænurus canens Walcott (p. 222).

3. Cranidium from Locality C54, Upper Cambrian, Ch'au-mi-tién limestone, two-thirds of a mile (1.1 km.) west of Tsi-nan, Shan-tung. U. S. Nat. Mus., Cat. No. 58279.

3*a*. Cranidium, × 2, from Locality C42, Upper Cambrian, Ch'au-mi-tién limestone, 7.5 miles (12 km.) east of Ch'au-mi-tién, Shan-tung. U. S. Nat. Mus., Cat. No. 58281.

3*b*. Pygidium (natural size) associated with specimen represented by fig. 3. From Locality C54. U. S. Nat. Mus., Cat. No. 58280.

3*c*. Pygidium from Locality C38, Upper Cambrian, Ch'au-mi-tién limestone at Ch'au-mi-tién, Shan-tung. U. S. Nat. Mus., Cat. No. 58282.

Illænurus ceres Walcott (p. 223).

4. Dorsal view and side outline of type specimen of cranidium, × 1.5, from Locality C38, Upper Cambrian, Ch'au-mi-tién limestone at Ch'au-mi-tién, Shan-tung. U. S. Nat. Mus., Cat. No. 58285.

4*a*. Pygidium associated with the specimen represented by fig. 4. U. S. Nat. Mus., Cat. No. 58286.

Illænurus dictys Walcott (p. 224).

5. Dorsal view and side outline of type specimen of cranidium, × 4. From Locality C56, Upper Cambrian, Ch'au-mi-tién limestone, west of Tsi-nan, Shan-tung. U. S. Nat. Mus., Cat. No. 58287.

5*a*. Pygidium associated with the specimen represented by fig. 5, × 3. U. S. Nat. Mus., Cat. No. 58288.

Illænurus sp. undt. Walcott (p. 222).

6. Large pygidium (natural size) from Locality C54, Upper Cambrian, Ch'au-mi-tién limestone, two-thirds of a mile (1.1 km.) west of Tsi-nan, Shan-tung. U. S. Nat. Mus., Cat. No. 58289.

Gen. and sp. undt. (*a*) **Walcott** (p. 224).

7. Pygidium of unknown generic and specific relations, × 4. From Locality C9, Middle Cambrian, Kiu-lung group, southwest of Yen-chuang, Sin-t'ai district, Shan-tung. U. S. Nat. Mus., Cat. No. 58290.

Gen. and sp. undt. (*b*) **Walcott** (p. 224).

8. Small pygidium of unknown generic and specific relations from Locality C67, Upper Cambrian, a piece of limestone in the drift, one-third of a mile (0.5 km.) west of the west city gate, Tsi-nan, Shan-tung. U. S. Nat. Mus., Cat. No. 58291.

Hysterolenus ? sp. undt. Walcott [see plate 22, figs. 9, 9*a*] (p. 219).

9. A beautifully ornamented pygidium of unknown specific relations, from Locality C64, Upper Cambrian, Ch'au-mi-tién limestone, 2.7 miles (4.3 km.) southwest of Yen-chuang, Shan-tung. U. S. Nat. Mus., Cat. No. 58268.

Aluta bergeroni (Walcott) (p. 225).

10. A minute left valve, greatly enlarged. (C32.) U. S. Nat. Mus., Cat. No. 56493.

Aluta enyo (Walcott) (p. 225).

11. A left valve, greatly enlarged, showing position of ocular tubercle and form of valve. (C32.) U. S. Nat. Mus., Cat. No. 56497.

Aluta eris (Walcott) (p. 226).

12. A fragmentary right valve, with outline restored to show the supposed form. (C32.) U. S. Nat. Mus., Cat. No. 56496.

Aluta fragilis (Walcott) (p. 226).

13. A right valve, illustrating manner in which the thin test is crushed by compression. (C32.) U. S. Nat. Mus., Cat. No. 56495.

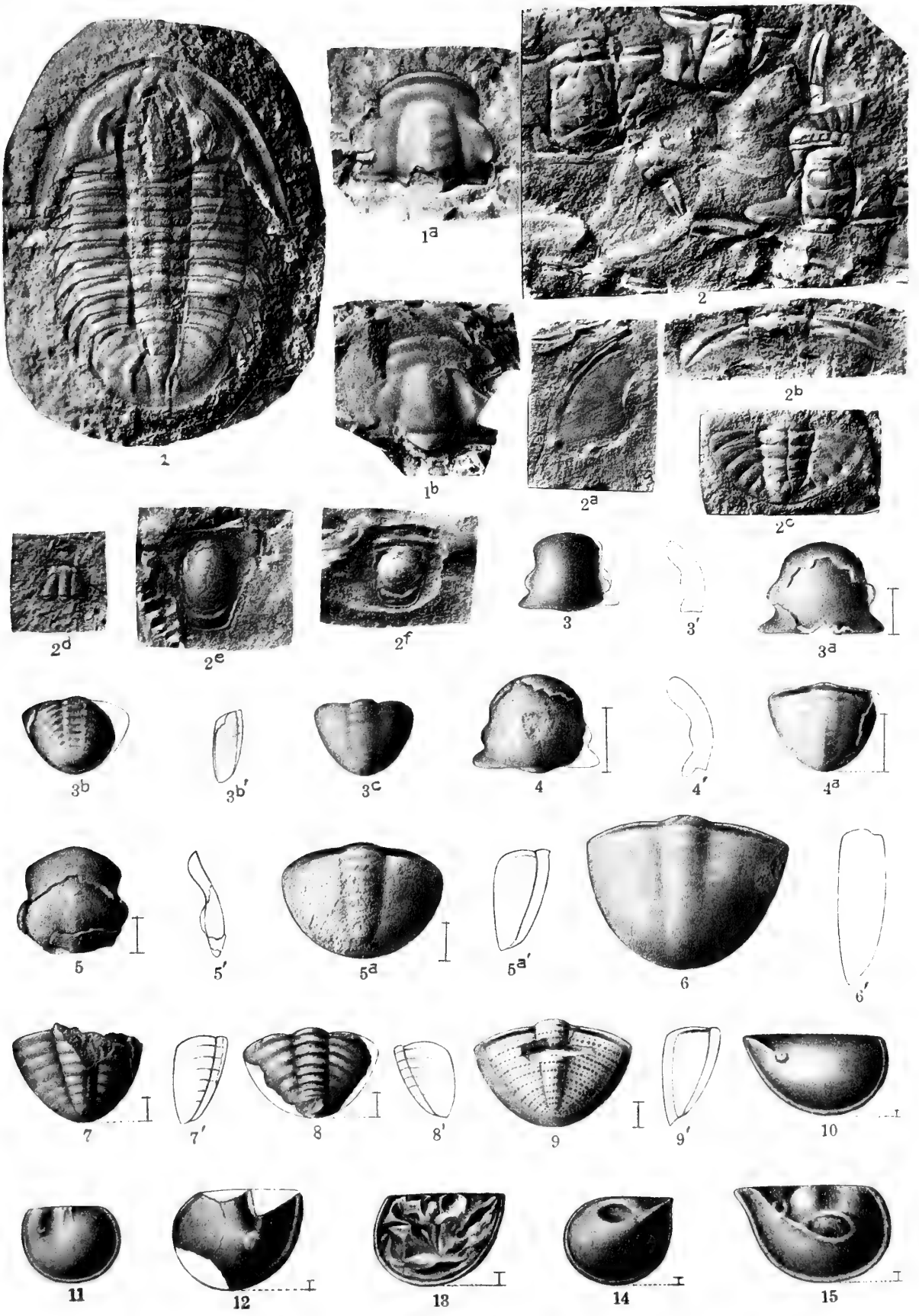
Aluta sterope (Walcott) (p. 227).

14. Right valve, showing the peculiar markings upon the surface. (C32.) U. S. Nat. Mus., Cat. No. 56498.

Aluta woodi (Walcott) (p. 227).

15. Left valve, showing ocular tubercle, and looped ridge extending from near anterior angle to center of valve. (C32.) U. S. Nat. Mus., Cat. No. 56494.

All of the specimens represented by figs 10–15 are from Locality C32, Middle Cambrian, river drift south of Chön-p'ing-hién, Shan-si.



COCKAYNE — BOSTON

Description of Plate 24.

Redlichia chinensis Walcott [see plate 7, figs. 11, 11*a–c*] (p. 104).

1. × 2. Nearly entire dorsal shield from near Yunnan-Fu, Yunnan, China. U. S. Nat. Mus., Cat. No 58792.

1*a*. × 2. Posterior portion of thorax and pygidium associated in the same bed with the specimen represented by fig. 1. U. S. Nat. Mus., Cat. No. 58793.

In a letter received from Dr. H. Mansuy since the text of this memoir was put in type he states that he had found a specimen of *Redlichia chinensis* on which the posterior five segments of the thorax have a well-marked, strong median spine comparable to that upon the corresponding parts of *Elliptocephala asaphoides* Emmons.*

Zacanthoides typicalis Walcott.

2. × 1.5. Dorsal view of type specimen from Locality 31, Lower Cambrian, Pioche shale, Pioche, Lincoln County, Nevada. U. S. Nat. Mus., Cat. No. 15454.

Zacanthoides idahoensis Walcott.

3. × 1.5. Thoracic segment of *Zacanthoides idahoensis* Walcott with a long median spine. Locality 55c, Middle Cambrian, Spence shale, 5 miles (8 km.) west-southwest of Liberty, Idaho. U. S. Nat. Mus., Cat. No. 53438.

Protolenus elegans Matthew.

4 and 4*a*. Cranidium, natural size and enlarged, × 2. U. S. Nat. Mus., Cat. No. 58794.

5. Flattened cranidium, natural size. U. S. Nat. Mus., Cat. No. 58795.

6. Free cheek associated with specimen represented by figs. 3 and 3*a*. U. S. Nat. Mus., Cat. No. 58796.

7. Enlargement of frontal limb of cranidium, × 7, to show the irregular, radiating raised ridges. U. S. Nat. Mus., Cat. No. 58797.

The specimens illustrated by figs. 4 to 7 are from the type locality of the genus (Middle Cambrian) on Hanford Brook, St. John County, New Brunswick.

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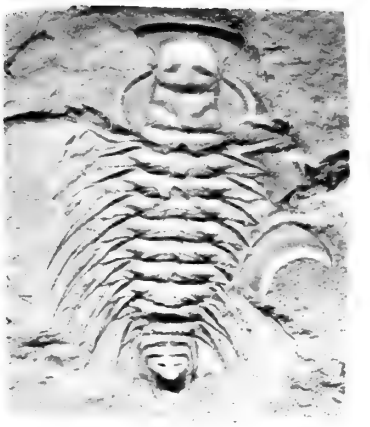
*Smithsonian Misc. Coll., vol. 53, No. 6, p. 269, pl. 24, figs. 1, 9.

1



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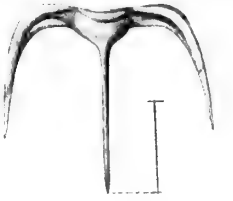


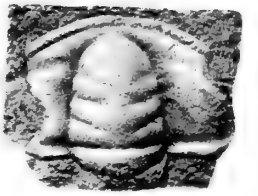
3

1a

4

4a

7



5

6

COCKAYNE—BOSTON

A REPORT ON ORDOVICIAN FOSSILS COLLECTED IN EASTERN ASIA IN 1903-04.

By Stuart Weller.

(Two Plates—Plates 25 and 26.)

A REPORT ON ORDOVICIAN FOSSILS COLLECTED IN EASTERN ASIA IN 1903-04.

The Ordovician fossils secured by the members of the Carnegie Institution of Washington expedition to Eastern Asia are comprised in two collections from two widely separated regions, one in the province of Shan-tung, the other in the extreme eastern portion of the province of Ssï-ch'uan. These two collections will be considered separately, as they contain very little in common.

COLLECTION FROM SHAN-TUNG.

The Shan-tung collections are all poorly preserved material, too imperfect for specific identification, but sufficient to demonstrate without question the Ordovician age of the rocks from which they were secured. Any closer correlation of the Tsi-nan limestones from which most of the specimens were collected can not be made with certainty, although it is probable that the formation belongs somewhere in the middle division of the Ordovician, or in what in North America is called Mohawkian. Several localities are represented in the collection, and the fauna from each of these will be considered in order.

Locality C 39.—Ch'au-mi-tién, Shan-tung, about 400 feet (121.9 m.) above the base of the Tsi-nan limestone.

1. *Orthoceras* sp. Two specimens, both of which are weathered longitudinal sections, poorly preserved.

Locality C 53.—Seven and a half miles (13 km.) south-southeast of Sin-t'ai-hién, Shan-tung, a few hundred feet below the top of the Tsi-nan limestone, the exact horizon not determined.

1. Gastropod. A cross-section of a small coiled shell upon the weathered surface of the limestone. Too imperfect for either generic or specific determination.
2. *Orthoceras* sp. Weathered longitudinal section similar to those of the last locality.

Locality C 59.—These fossils were found in loose rubble lying upon outcrops of the Tsi-nan limestone, 1 mile (1.6 km.) northeast of Ts'ai-kia-chuang, Shan-tung. The material consists of limestone and cherts. The limestone specimens are undoubtedly of Ordovician age, but the cherts seem to be Carboniferous and were doubtless derived from the Carboniferous rocks which are exposed only a few miles distant. The fossils recognized in the limestone are as follows:

1. *Orthis* ? or *Dalmanella* ? sp. An imperfect impression of a single valve of a brachiopod shell. It appears to be an orthid, and probably belongs either to the genus *Orthis* or to *Dalmanella*, but it is too imperfect for certain generic or specific determination.

2. *Maclurea* ? or *Helicotoma* ? sp. A flat-coiled gastropod shell represented by a cross-section upon the weathered surface of the limestone. Neither the generic nor specific relations of the shell can be determined, but it probably belongs to one of the two genera *Maclurea* or *Helicotoma*, both of which are Ordovician forms; if it is a *Maclurea* it is a very small species of the genus.
3. *Lophospira* sp. This is a longitudinal section of a moderately high spiral shell with angular volutions, which is almost certainly a *Lophospira*, although its specific characters can not be distinguished.
4. *Orthoceras* sp. Imperfect longitudinal sections upon the weathered surface of the limestone, similar to those at Localities C39 and C53.
5. *Asaphus* ? sp. An imperfect cranidium of a trilobite. It is certainly one of the asaphids, but its true generic relations are not clear, and it is too incomplete for specific determination.

Locality C 64.—Two and seven-tenths miles (4.3 km.) southwest of Yen-chuang, Shan-tung. Upper part of Ch'au-mi-tién limestone.

1. *Orthoceras* sp. Longitudinal sections of two examples upon the weathered surface of the limestone. Both specimens are rather small and slender forms, the maximum width of each being about 6 mm.; they probably belong to two species, one of which has much closer septa than the other.

Locality C 65.—Five and a half miles (9.8 km.) southwest of Tsi-nan, Shan-tung, from the Tsi-nan limestone.

1. *Strophomena* ? sp. Several imperfect fragments of a brachiopod shell upon the weathered surfaces of the limestone, all of which are too imperfect for certain identification.
2. *Orthoceras* sp. A very imperfect longitudinal section upon the weathered surface of the limestone.

Locality C ?—A limestone fragment collected from gravel in the valley of a dry stream, 4.8 miles (7.6 km.) west-southwest of Tsi-nan, Shan-tung.

1. *Orthoceras* sp. A weathered longitudinal section of a specimen having a maximum diameter of 55 mm.

COLLECTION FROM SSÏ-CH'UAN.

The Ssï-ch'uan collections are from two localities on the Ta-ning River near Sü-kia-pa, in the extreme eastern portion of the province. The fossils occur in the uppermost layers of the Ki-sin-ling limestone, a massive formation of dark color 3,500 feet (1,066.7 m.) in thickness, which rests conformably upon subjacent beds of Cambrian age. The material collected, although not extensive in amount, affords data of great importance and is sufficient to admit of a fairly approximate correlation of the limestones in which the fauna occurs. The fauna from the two localities, which are scarcely 2 miles (3.2 km.) apart, are much alike and indicate essentially the same horizon.

Locality 20/C is in a gulch just northeast of Sü-kia-pa, and has furnished the following species:

Strophomena sp. undt.
Triplecia poloi Martelli
Orthis calligramma Dalman
Plectorthis willisi Weller
Dalmanella testudinaria (Dalman)
Dalmanella subæquata (Conrad)
Clitambonites chinensis Weller
Hemipronites tenuistriata Weller
Gastropod (gen. and sp. undt.)
Cyrtodonta ? sp. undt.
Ampyx chinensis Weller
Bathyurus sp. undt.
Asaphus sp. cf. *A. expansus* Dalman
Asaphus asiaticus Weller
Asaphus chinensis Weller
Asaphus several spp. undt.
Isotelus sp. undt. (hypostome)
Isotelus sp. undt. (pygidium)
Illænus ? *bronteoides* Weller
Proetus ? sp. undt.
Calymene ? sp. undt.
Pterygometopus ? sp. undt.

Locality 20/B is at the narrows in the river about 1.5 miles (2.4 km.) above Sü-kia-pa, and has furnished the following species:

Lingula ? sp. undt.
Strophomena sp. undt.
Plectorthis willisi Weller
Dalmanella testudinaria (Dalman)
Clitambonites chinensis Weller
Cornulites sp. undt.
Gastropod (gen. and sp. undt.)
Vaginoceras sp. undt.
Ampyx sp. cf. *A. costatus* Boeck
Asaphus blackwelderi Weller
Asaphus taningensis Weller
Asaphus lævis Weller
Asaphus several spp. undt.
Megalaspis minor Weller
Proetus sp. undt.

DESCRIPTIONS OF SPECIES FROM THE KI-SIN-LING LIMESTONE.

Lingula ? sp. undt.

A single imperfect specimen of a small inarticulate brachiopod may be referred provisionally to the genus *Lingula*. It is shorter and rounder than usual for the members of that genus, and if its characters could be accurately determined it might be referred elsewhere.

Strophomena sp. undt. (plate 25, figs. 1, 2).

The specimens of this species are somewhat common in this collection, but all are poorly preserved. They can not be definitely identified with any of the described species, but are somewhat closely allied to such forms as *S. incurvata* (Shepard) from the Mohawkian faunas of North America. One of the most complete specimens, a brachial valve, has a length of 14 mm., a width of 20 mm., and a convexity of 3.5 mm. A few other individuals were somewhat larger, but the dimensions given seem to indicate about the average size, which is smaller than is usual among the allied American species. The surface of the shells is marked by fine radiating costæ which, in specimens not too much exfoliated, are variable in size, from two to six finer costæ lying between the coarser ones; the surface is also marked by finer concentric lines, as in the American *S. incurvatus*. The greatest convexity of the brachial valve is anterior to the middle, and the cardinal extremities are compressed. The outlines of different individuals vary somewhat, and it is possible that more than one species is present in the fauna.

Triplecia poloi (Martelli) (plate 25, figs. 7–9).

1901. *Schizophoria poloi* Martelli, Boll. della Soc. Geol. Ital., vol. xx, p. 302, plate 4, figs. 17–22.
1901. *Porambonites intercedens* Martelli (not Pander), Idem, vol. xx, p. 304, plate 4, figs. 13–16.

Shell large, broader than long, subelliptical in general outline, the hinge-line about one-half as long as the width of the shell, the cardinal extremities rounded. Pedicle valve depressed-convex on the umbo, with a broad and profound mesial sinus toward the front, the surface of the valve anteriorly which slopes toward the sinus being about three-fourths of the total width of the shell; the beak rather obtuse and slightly incurved; the cardinal area small and apparently with rounded cardinal margins. Brachial valve strongly convex, most prominent along the median line, the mesial fold broad and scarcely differentiated from the lateral slopes; beak small, slightly incurved. Surface of both valves apparently smooth.

The dimensions of a pedicle valve are: length 16 mm., width 24 mm., depth of valve at umbo 5 mm. The dimensions of a smaller brachial valve are: length 11 mm., width 14 mm., convexity 4.5 mm.

The specimens from Ssï-ch'uan which have been identified with this species described by Martelli from southern Shen-si are all more or less imperfectly preserved, but, aside from their somewhat smaller size, they seem to be identical with Martelli's examples. That author seems to have been in error in referring his specimens to two distinct species belonging to different genera, since his *Schizophoria poloi* and *Porambonites intercedens*, judging from his illustrations alone without an examination of the original material, seem to be based upon differences which can be legitimately considered only as individual variations. Furthermore, both of his generic references seem to be incorrect, the species being a good example of *Triplecia*.

This species is of the general form of the North American *T. extans* Emmrich from the Trenton limestone, but the sinus of the pedicle valve is less angular and somewhat broader and the fold of the brachial valve rounder and less sharply differentiated from the lateral slopes. The cardinal margins of the pedicle valve seem also to be rounded and not angular, as in the North American species, but this character can not be certainly determined in the condition of preservation of the specimens. The surface characters of the shell are also obscure because of exfoliation, but the shells seem to be smooth, except for some obscure lines of growth.

Orthis calligramma Dalman (plate 25, figs. 3–6).

1845. *Orthis calligramma* de Verneuil, Geol. Russia and Ural Mts., vol. II, p. 207.
1859. *Orthis calligramma* Murchison, Siluria, p. 209, plate 5, fig. 8.
1869. *Orthis calligramma* Davidson, Brit. Sil. Brach., vol. III, p. 240, plate 35, figs. 1–24 (in part).
1883. *Orthis calligramma* Kayser, Richthofen's China, vol. IV, p. 40, plate 3, fig. 12.
1901. *Orthis calligramma* var. *serica* Martelli, Boll. della Soc. Geol. Ital., vol. XX, p. 297, plate 4, figs. 1–4.
1901. *Orthis calligramma* var. *davidsoni* Martelli, Idem, vol. XX, p. 301, plate 45, figs. 5, 6.

The specimens of this species contained in the Chinese collection agree closely with the typical form of the species as interpreted by de Verneuil in the Geology of Russia.[1] The dimensions of an average specimen in the Chinese collection are: length 8.5 mm., width 11 mm. They are marked by 20 to 25 simple rounded plications, the interstices being occupied by three or four longitudinal striæ. The pedicle valve is the most strongly convex, with the beak incurved and extending backward beyond the hinge-line; in none of the specimens has the cardinal area been observed. The brachial valve is nearly flat or slightly convex and usually has a broad mesial flattening or slight depression.

This species is a common and variable one in some of the Ordovician faunas of Europe, both in Great Britain and on the continent, but it has never been recognized in its typical form in the North American faunas. The specimens from eastern Ssï-ch'uan closely resemble, in all essential details, Martelli's illustrations of the same species from Shen-si and also Kayser's from further west in Ssï-ch'uan.

[1] Geol. Russia and the Ural Mountains, vol. II, p. 207.

Plectorthis willisi Weller (plate 25, figs. 10, 11).

1907. *Plectorthis willisi* Weller, Proc. U. S. Nat. Mus., vol. xxxii, p. 557.

Shell transversely subelliptical in outline, the hinge-line a little shorter than the greatest width, cardinal extremities slightly rounded. Pedicle valve depressed-convex, slightly compressed toward the cardinal extremities; the beak small, scarcely incurved, cardinal area a little concave, sloping backward at an angle of about 40° to the plane of the valve; cardinal margins angular. Brachial valve nearly as convex as the pedicle, compressed toward the cardinal extremities. Surface of each valve marked by from 20 to 25 major radiating, rounded costæ, which increase in width conspicuously in passing from the beak to the front margin; in each interspace between these major costæ from one to three smaller ones which do not reach the beak are intercalated. The more minute surface markings are destroyed. The dimensions of a pedicle valve are: length 7.5 mm., width 12 mm., height of area 1 mm., convexity 2 mm.

The most notable feature of this shell is the conspicuous broadening of the major costæ in passing from the beak to the front margin.

Dalmanella testudinaria (Dalman) (plate 25, figs. 12–16).

1828. *Orthis testudinaria* Dalman, Kongl. Svenska Vet.-Skad. Handl. för 1827, p. 115, plate 2, fig. 4.
1847. *Orthis testudinaria* Hall, Pal. N. Y., vol. I, p. 117, plate 32, fig. 1; p. 288, plate 79, fig. 4.
1863. *Orthis testudinaria* Billings, Geol. Canada, p. 165, fig. 144.
1869. *Orthis testudinaria* Davidson, Brit. Sil. Brach., vol. III, p. 226, plate 28, figs. 13–24.
1882. *Orthis testudinaria* Whitfield, Geol. Wis., vol. IV, p. 258, plate 12, figs. 5–7.
1884. *Orthis testudinaria* Walcott, Monog. U. S. G. S., vol. VIII, p. 72, plate 11, fig. 10.
1892. *Dalmanella testudinaria* Hall and Clarke, Pal. N. Y., vol. VIII, pt. I, pp. 190, 206, 218, 224, plate 5B, figs. 27–39.
1893. *Orthis* (*Dalmanella*) *testudinaria* Winchell and Schuchert, Minn. Geol. Survey, vol. III, pt. III, pp. 177, 241.
1897. *Orthis testudinaria* Sardeson, Am. Geol., vol. XIX, p. 92.
1903. *Dalmanella testudinaria* Weller, Pal. N. J., vol. III, p. 155, plate 10, figs. 1, 2.

This species is one of the most widely distributed brachiopods found in strata of Ordovician age, it being recognized throughout the world wherever middle Ordovician strata are known. In the fauna of the Ki-sin-ling limestone it is the most abundant species. The specimens agree well with representatives of the same species from North America, but are, on the average, perhaps, slightly more elongate. The average size of the specimens in the collection is about 13 mm. in length and 14 mm. in width.

Dalmanella subæquata (Conrad) (plate 25, figs. 19, 20).

1843. *Orthis subæquata* Conrad, Proc. Acad. Nat. Sci. Phila., vol. I, p. 333.
1847. *Orthis subæquata* Hall, Pal. N. Y., vol. I, p. 118, plate 32, fig. 2.
1862. *Orthis subæquata* Hall, Geol. Wis., vol. I, p. 42, figs. 1–3, and p. 436.
1892. *Dalmanella subæquata* Hall and Clarke, Pal. N. Y., vol. VIII, pt. I, pp. 194, 207, 224, plate 5C, figs. 6–11.
1893. *Orthis* (*Dalmanella*) *subæquata* Winchell and Schuchert, Minn. Geol. Surv., vol. III, p. 446, plate 33, figs. 30–36.
1903. *Dalmanella subæquata* Weller, Pal. N. J., vol. III, p. 156, plate 10, figs. 3–4.

In North America this species is a variable one, no less than four named varieties being recognized by Schuchert in his "Synopsis of American Fossil Brachiopoda." The Chinese specimens are entirely similar to American ones and agree for the most part with the typical form of the species, though some of those with slightly coarser costæ might perhaps be referred to the variety *pervetus*. The *gibbosus* variety with well-developed sinus has not been detected in the Chinese collection.

Clitambonites chinensis Weller (plate 25, figs. 17, 18).

1907. *Clitambonites chinensis* Weller, Proc. U. S. Nat. Mus., vol. xxxii, p. 558.

Shell broader than long, the hinge-line straight, the greatest width at the hinge-line or a little in front of it, the lateral and anterior margins describing a regular

curve. Pedicle valve strongly elevated at the beak, the surface sloping from the umbo to the anterior and antero-lateral margins with a slightly convex curve, sometimes becoming a little concave as it approaches the anterior margin, the slope to the cardinal extremities somewhat more abrupt; cardinal area large, flat, sloping posteriorly from the hinge-line in one specimen at an angle of 102° and in another at an angle of 115° to the plane of the valve, the cardinal margins sharp; delthyrium rather narrow, closed with a strongly convex deltidium, foramen terminal, encroaching upon the umbo; median septum inconspicuous; muscular impressions indefinite, rather large, and flabelliform. Surface of each valve marked by fine radiating costæ, two or three of which occupy the space of 1 mm.

The dimensions of two pedicle valves are: length 15 mm. and 14 mm., width 18.7 mm. and 16.9 mm., height of cardinal area 5 mm. and 5 mm., greatest width of deltidium 3 mm. and 2.5 mm. The dimensions of a brachial valve are: length 16.5 mm., width 21 mm., convexity 4 mm.

This species is represented in the collection by only a small number of specimens, none of which are as well preserved as might be desired. It differs especially from other members of the genus in the terminal position of the pedicle opening, the pedicle apparently having passed through the foramen in a direction continuous with the surface of the deltidium and not at an angle to it, as is usually the case. This position of the pedicle also seems to have modified the position of the spondylium, its surface being nearly vertical to the inner surface of the valve, in consequence of which the median septum becomes essentially obsolete.

Hemipronites tenuistriata Weller (plate 25, figs 21–24).

1907. *Hemipronites tenuistriata* Weller, Proc. U. S. Nat. Mus., vol. xxxii, p. 559.

Shell wider than long, the valves subequally convex, the hinge-line a little shorter than the greatest width, the cardinal extremities subangular. Pedicle valve most prominent on the umbo, the beak rather obtuse, the surface sloping from the umbo laterally and anteriorly with a gently convex curve; a slight, scarcely noticeable mesial flattening of the valve occurs toward the front, but no mesial sinus is present; cardinal area flat, rather large, with a broad deltidium, the cardinal margins angular. Brachial valve most prominent along the median line, but with no differentiated median fold, the greatest convexity at about the mid-length of the valve, the surface slightly compressed toward the cardinal extremities. Surface of each valve marked by exceedingly fine striæ which are scarcely visible to the naked eye, about eight occupying the space of 1 mm.

The dimensions of a pedicle valve are: length 16 mm., width approximately 17.5 mm., convexity 5 mm., height of cardinal area 3 mm., length of hinge-line 15 mm. The dimensions of a brachial valve are: length 17 mm., width 22 mm., convexity 5 mm.

The specimens of this species in the collection are all too poorly preserved to allow the determination of its generic position with entire satisfaction. They have, however, the general form of European members of the genus *Hemipronites* and it is believed that this generic reference is correct, but the nature of the deltidium and the presence or absence of a foramen can not be certainly determined. The genus *Hemipronites* has not been recognized in the American faunas, and is known especially from the Baltic provinces in Russia. The species is evidently congeneric with the shell which Martelli has called *Orthisina giraldii*,[1] and the two species are closely allied. The species here described, however, is somewhat more finely striate, and it seems to be relatively a somewhat broader shell.

[1]Boll. della Soc. Geol. Ital., vol. xx (1901), p. 305.

Cornulites sp. undt. (plate 26, fig. 1).

A single imperfect specimen of an annelid tube, apparently a member of the genus *Cornulites*, occurs in the collection. Its diameter is 2.5 mm., and the specimen as preserved is about 13 mm. long, the sides tapering very slightly in this length. The shell is marked by annular ridges about 1 mm. apart and by much finer annular striæ which cover both the elevated annular ridges and the depressions.

Gastropod gen. and sp. undt.

A few fragments of gastropod shells occur in the collection, too imperfect for generic determination. All the specimens are apparently portions of flat-coiled species and none of them could have been more than 15 mm. in diameter.

Cyrtodonta ? sp. undt. (plate 26, fig. 2).

A single pelecypod shell occurs in the collection, too incomplete for identification, although it seems to have something of the form of some of the American species of *Cyrtodonta*. The dimensions of the specimen can not be accurately determined, but its length was apparently about 15 mm. and its height about 13 mm. The surface is marked by rather conspicuous lines of growth and by much finer radiating lines.

Vaginoceras sp. undt.

Several fragmentary specimens of the invaginating cones of the siphuncle of a member of this genus are present in the collection. The maximum diameter of the specimens preserved is 13 mm.

Ampyx chinensis Weller (plate 26, fig. 16).

1907. *Ampyx chinensis* Weller, Proc. U. S. Nat. Mus., vol. XXXII, p. 559.

Cranidium subsemicircular in outline, width 6.8 mm., length 3.5 mm. Glabella prominent, produced anteriorly somewhat beyond the frontal margin, subangular along the dorsal median line, the sides convex and sloping rather abruptly to the dorsal furrows; at the anterior termination of the glabella is the fractured base of a slender cylindrical spine whose length can not be determined; lateral furrows obsolete. Occipital furrows narrow and shallow. Occipital segment very short. The fixed cheeks are broad, convex, and subtriangular in outline, marked by postmarginal furrows which continue from the extremities of the occipital furrow.

This species is a close ally of *A. nasutus* Dalman, but it differs from all illustrations of that species in its proportionately greater width. The free cheeks, thorax, and pygidium have not been observed, the species being founded upon a single, nearly perfect cranidium.

Ampyx sp. cf. **A. costatus** Boeck.

Two fragmentary specimens of the cranidia of a larger species of *Ampyx* than that last described occur in the collection. So far as they are preserved they resemble the illustrations of *A. costatus* given by Schmidt,[1] but they are too incomplete for certain identification.

Bathyurus sp. undt. (plate 26, figs. 17, 18).

A minute trilobite cranidium 2 mm. in length is apparently a member of the genus *Bathyurus*. The glabella is smooth, strongly convex, with the two pairs of lateral furrows almost obsolete. The occipital segment is rather broad and is apparently smooth; the cheeks have been almost entirely destroyed.

[1]Rev. Ostbalt, Sil. Tril., pt. 4, plate 6, figs. 24, 25.

Asaphus blackwelderi Weller (plate 26, figs. 21, 22).

1907. *Asaphus blackwelderi* Weller, Proc. U. S. Nat. Mus., vol. XXXII, p. 560.

Cranidium comparatively short and broad with the axis obsolete, obtusely angular in front, the palpebral lobes large and prominent, their anterior margins nearly opposite the middle point of the head; in front of the eyes the lateral margins diverge gradually to a point nearly half-way to the anterior margin, where they are rather broadly rounded and then converge somewhat abruptly to the anterior extremity; back of the eyes the lateral margins diverge rapidly and curve backward to the posterior margin, the width of the cranidium along its posterior margin being considerably greater than the distance between the eyes. The occipital furrow and segment are faintly developed. A slight median tubercle is situated at a point about half-way between the line joining the posterior extremities of the eyes and the posterior margin, aside from which the surface of the cranidium is apparently smooth.

A free cheek is associated with this cranidium and possibly belongs to the same species; its lateral region is differentiated as a rounded marginal border, and its genal angle is produced into a rather strong genal spine.

The dimensions of the cranidium described are: length 8 mm., width between the eyes 6 mm., width along posterior margin 7.5 mm.

The outline of the cranidium upon which this species is established somewhat closely resembles that of *A. expansus* Dalman, the typical species of the genus, and both species are marked by a similar small median tubercle near the posterior margin. This Chinese species may be distinguished from its European ally, however, on account of the obsolete glabella. If the free cheek which occurs with *A. blackwelderi* really belongs to the species, this also will serve to distinguish the two forms by reason of its strongly developed genal spine, these spines being absent from the European species. This cranidium should possibly be associated with one of the pygidia described in the present paper, possibly with the one which has been compared with *A. expansus*, although the cranidium does not occur in the same locality with these pygidia in the collections studied.

Asaphus taningensis Weller (plate 26, figs. 19, 20).

1907. *Asaphus taningensis* Weller, Proc. U. S. Nat. Mus., vol. XXXII, p. 561.

Cranidium rather long and slender, with the axis nearly obsolete; the palpebral lobes apparently rather small, situated back of the mid-length of the head. In front of the eyes the lateral margins of the cranidium describe the two sides of an ovate curve, gently diverging from the anterior extremities of the eyes, then broadly rounding and converging abruptly in front to the obtusely subangular anterior extremity; back of the eyes the lateral margins diverge abruptly with a gently convex curve to the posterior margin. Anteriorly the surface of cranidium is somewhat flattened to form an indistinct anterior limb. Occipital furrow and segment nearly obsolete. A faint median tubercle is situated on the median line of the head about half-way between the line joining the posterior extremities of the eyes and the posterior margin, but aside from this the surface of the cranidium is smooth.

The dimensions of the type specimen are: length of cranidium 11 mm., width at posterior margin 11.5 mm., width between the eyes 7 mm.

This species is known only from the cranidium and it is of course possible that it should be correlated with some of the species here described from the pygidium alone. The only one of these pygidia, however, which is recognized from exactly the same locality as this species is *A. lævis*, which is such a short form that it is not at all likely to be a portion of the same species as this elongate cranidium. The species should perhaps be referred to the genus *Megalaspis* rather than *Asaphus*, but this can not be determined from such incomplete material.

Asaphus sp. cf. **A. expansus** Dalman (plate 26, figs. 3, 4).

This species is represented in the collection by two specimens, both of them pygidia and both of them more or less incomplete. The dimensions of the two individuals are: length 12 mm. and 7.25 mm., width 19 mm. and 15.5 mm. The width of the axis anteriorly is 7 mm. and 3.5 mm. The axis is bordered by rather broadly rounded, impressed axial furrows, and its posterior extremity is about 2 mm. from the posterior margin. The segmentation of the axis is obscure, but about seven or eight annulations can be detected, the more posterior ones being almost obsolete; upon the pleural slopes two or three obscure segments can be detected anteriorly.

These pygidia are too imperfect to be identified with certainty as *A. expansus*, but if they do not belong to that species they certainly represent a closely allied form. They are quite different from any of the North American Asaphidæ, in fact no member of the genus *Asaphus* in its strict sense is present in any of the American faunas.

Asaphus asiaticus Weller (plate 26, fig. 5).

1907. *Asaphus asiaticus* Weller, Proc. U. S. Nat. Mus., vol. xxxii, p. 561.

Pygidium subsemielliptical in outline, moderately convex, the axis depressed, bordered by rather broadly rounded axial furrows which become obsolete posteriorly; pleural slopes prominent just outside the axial furrows, then sloping with a convex surface to the margins, without a differentiated marginal border. Axis occupying about one-third the total width of the pygidium anteriorly, tapering posteriorly to a bluntly rounded point, divided by rather broad and shallow, obscure furrows into twelve segments. Pleural slopes divided into about twelve obscure segments which reach less than half-way from the axial furrows to the margins; the most anterior furrow crossing the pleural slope is broad and deep, being much more conspicuous than those behind.

The dimensions of the type specimen, an incomplete pygidium, are: length 20.5 mm., width about 30 mm., width of axis anteriorly 10 mm., length of axis 16 mm.

This species is known only from the pygidium which is much like that of the European *A. expansus*, being distinguished chiefly by its greater proportional length and by the more obscure segmentation of the pygidium.

Asaphus lævis Weller (plate 26, fig. 6).

1907. *Asaphus lævis* Weller, Proc. U. S. Nat. Mus., vol. xxxii, p. 562.

Pygidium nearly semicircular in outline. The axis depressed, without segmentation, poorly defined by the nearly obsolete axial furrows, occupying about one-fourth of the total width of the pygidium anteriorly; pleural slopes smooth, without segmentation, convex toward the axis but becoming depressed in a broad, moderately concave marginal border toward the outer margin. The posterior extremity of the axis reaches the inner margin of the concave border.

The dimensions of the type specimen are: length 12 mm., width 23 mm., width of axis anteriorly 5.5 mm., length of axis 8.5 mm., width of concave marginal border about 3.5 mm.

This species is represented in the collection by a single nearly complete pygidium. So far as can be determined it seems to be a member of the genus *Asaphus* in its strict sense, the species being especially characterized by its remarkably smooth surface.

Asaphus chinensis Weller (plate 26, fig. 7).

1907. *Asaphus chinensis* Weller, Proc. U. S. Nat. Mus., vol. xxxii, p. 562.

This species is founded upon a single, nearly perfect pygidium and is much like the last-described form. It differs in its proportions, however, its dimensions being:

length 14 mm., width 22.5 mm., width of axis anteriorly 6.8 mm., length of axis 9.5 mm., width of concave marginal border about 4 mm. The most marked differences between the two species are the much more conspicuous concave border in *A. chinensis*, and the slight though obscure traces of segmentation upon both the axis and the pleural slopes. This latter character, however, may be due to the removal of the test from the central portion of the specimen, and if the external surface were preserved it might be as smooth as *A. lævis*.

Asaphus sp. undt. (plate 26, fig. 9).

A small pygidium may be referred provisionally to the genus *Asaphus* and it may be an immature individual of one of the larger forms already described. It is semicircular in outline, with a slightly concave, sloping marginal border. The axis is rather sharply defined but not greatly elevated, and is divided into eight or nine indistinct segments. The pleural slopes are smooth. The dimensions of the specimen are: length 3.5 mm., width 5.5 mm.

Asaphus sp. undt. (plate 26, fig. 14).

A nearly complete hypostome may be referred to this genus, and it possibly belongs to one of the associated species that have been described from the pygidia. The specimen has a moderately deep emargination in front and has the central portion strongly differentiated from the lateral expansions, these characters serving to distinguish it from a much larger *Isotelus*-like hypostome with which it is associated. The dimensions of the specimen are: length 7.5 mm., width 6 mm., depth of emargination 2 mm.

Asaphus ? sp. undt.

In addition to the asaphids already noted, several other species are represented in the collections, all of them in a fragmentary condition, some of which are clearly distinct from any of those described. Two incomplete free cheeks and an eye occur which may or may not belong to some of the forms described from pygidia or cranidia, also two or three incomplete pygidia and an incomplete cranidium.

Isotelus ? sp. undt. (plate 26, fig. 13).

A very imperfect specimen of a small *Isotelus*-like pygidium is included in the collection. It is a mere fragment, yet so far as it is preserved it is not unlike a small example of the North American species *I. gigas*.

Isotelus sp. undt. (plate 26, fig. 15).

An incomplete specimen of a large forked hypostome is evidently from a species of this genus. The extreme width of the specimen is about 34 mm., the depth of the emargination 18 mm., and its width externally 25 mm. This hypostome closely resembles that of the North American species *I. gigas*, but it is too incomplete for certain specific identification.

Megalaspis minor Weller (plate 26, fig. 8).

1907. *Megalaspis minor* Weller, Proc. U. S. Nat. Mus., vol. xxxii, p. 563.

Pygidium small, subelliptical in outline. Axis scarcely elevated above the general surface, about one-third of the total width of the pygidium anteriorly, tapering to the rather bluntly rounded posterior extremity, divided by nearly obsolete depressions into eight or nine obscure segments. Pleural slopes regularly convex from the sides of the axis to the margins, without a differentiated marginal border,

marked by about six narrow, faint, grooved segments which reach half-way across the slopes. Anteriorly, close to the margin and parallel with it, a subangular groove extends from each side of the axis about half-way across the pleural slopes; in front of and outside the lateral extremities of these grooves the surface is abruptly compressed.

The dimensions of the type specimen are: approximate length 9 mm., width 14.5 mm., width of axis anteriorly 4.8 mm., length of axis 7 mm.

This species is known only from the pygidium, and even that portion is incomplete. It is referred to the genus *Megalaspis* by reason of the grooved pleural segments. The segmentation is very faint and would probably be even less distinct or perhaps obsolete entirely were the test of the specimen preserved.

Illænus ? bronteoides Weller (plate 26, fig. 10).

1907. *Illænus ? bronteoides* Weller, Proc. U. S. Nat. Mus., vol. xxxii, p. 563.

Pygidium subsemicircular in outline, flattened on top. Axis ill-defined, unsegmented, occupying a little less than one-third the total width of the pygidium anteriorly, very slightly elevated in front and merging into the general surface of the pygidium posteriorly. Pleural slopes flattened on each side of the axis, sloping to the margins exteriorly with a slightly concave slope. The surface of each pleural slope, when the test is removed, is marked by about 12 or 13 very narrow and scarcely elevated ribs which are grooved longitudinally and extend from the indefinite axial furrows about to the line where the surface begins its more abrupt slope to the lateral margins.

The dimensions of the type specimen are: length 8.5 mm., width 14.8 mm., width of axis anteriorly 4.5 mm.

This species is represented by a single specimen in the collection, a nearly complete pygidium. It is a peculiar form having the general contour of an *Illænus*, but with the pleural slopes faintly segmented, suggesting the genus *Bronteus*. These segments are very faint, however, and would possibly not be visible at all were the specimen completely covered with the test.

Proetus ? sp. undt. (plate 26, fig. 11).

A nearly complete pygidium is referred with some hesitation to the genus *Proetus*. It is semielliptical in outline, 6.5 mm. long, and 8 mm. wide. The surface is regularly convex with a concave marginal border, the axis being but slightly elevated above the pleural slopes. The axis is divided into about twelve segments and terminates in a bluntly rounded point just within the marginal border. The pleural slopes are marked off by about nine segments somewhat fainter than those of the axis, and reach to the marginal border. In some respects this pygidium suggests some of the asaphids, but without additional material its true relationships can not be certainly established.

Calymene ? sp. undt.

A very incomplete pygidium of a trilobite seems to represent a species of *Calymene*, although it is too imperfect to allow even the generic identification to be made with certainty.

Pterygometopus ? sp. undt. (plate 26, fig. 12).

A single imperfect pygidium seems to be referable to this genus. The specimen has a well-defined axis with 12 annulations, the pleural slopes being divided into 9 segments without longitudinal grooves.

CORRELATION OF THE FAUNA OF THE KI-SIN-LING LIMESTONE.

A small Ordovician fauna from southern Shen-si has been described by Martelli,[1] with which this fauna from the Ki-sin-ling limestone must be compared. Only six species have been recorded by Martelli, four of which are brachiopods, with one bryozoan and one annelid tube; of one of the brachiopods two varieties are recognized. Martelli's list of species is as follows:

Orthis calligramma Dalman, var. *serica* var. nov.
Orthis calligramma Dalman, var. *davidsoni* de Verneuil
Schizophoria poloi sp. nov.
Porambonites intercedens Pander
Orthisina giraldii sp. nov
Fenestella ambigua Hall
Spirorbis inornatus Hall

It is scarcely worth while to recognize the two varieties of *Orthis calligramma* as distinct; the species is frequently more or less variable, and the Shen-si examples seem to be essentially like those collected by the members of the Carnegie Institution of Washington Expedition, and all these Chinese specimens closely resemble those from Russia illustrated by de Verneuil. The *Orthisina giraldii* of Martelli is apparently a true *Hemipronites*, and is a very close ally of the species described in the present paper as *H. tenuistriatus*. The examples of *Porambonites intercedens* and *Schizophoria poloi* of Martelli's list seem both to be representatives of a single species with which one of the brachiopods collected in Ssï-ch'uan by Mr. Blackwelder is apparently identical; the species, however, should undoubtedly be referred to the genus *Triplecia*. The two additional species of Martelli's list, *Fenestella ambigua* and *Spirorbis inornatus*, have no representatives in the Ssï-ch'uan fauna, and the identity of these Chinese examples, associated as they are with typical Ordovician brachiopods, with species described by Hall from the Niagaran of North America, is extremely doubtful, to say the least.

The essential species in Martelli's list, therefore, which must be considered in a comparison of the Shen-si fauna with that of Ssï-ch'uan, are only three in number—*Orthis calligramma*, *Hemipronites giraldii*, and *Triplecia poloi*. Of these species two are recognized in the present Ssï-ch'uan fauna and the third, *Hemipronites giraldii*, has a very close ally in *H. tenuistriatus;* the faunas from the two localities may be safely considered as marking the same geologic horizon and in all probability the same limestone formation. The two localities, indeed, are situated in the same general region of China, Martelli's specimens having come from a locality in the Ts'in-ling Mountains to the north of the Han River Valley, while the collection described in the present paper came from the southern side of the same valley; the two localities probably are not over 200 miles (320 km.) apart and may perhaps be even more nearly approximate.

Several small collections of fossils secured by Baron von Richthofen in northern Ssï-ch'uan, from the region about Tshau-tién, have been described by Kayser,[2] this locality being about 300 miles (480 km.) west of Ta-ning, near

[1]Fossili del Siluriano Inferiore dello Schensi (Cina), by Alessandro Martelli, Boll. della Soc. Geol. Ital., vol. xx (1901), pp. 295–310, pl. iv.

[2]Mittel- und Obersilurische Versteinerungen aus dem Gebirgsland von Tschau-tien, by Emanuel Kayser (Richthofen's China, vol. iv, pp. 37–74, plates 2, 3, 4).

which place the collections were made by the Carnegie Institution of Washington Expedition. These fossils are from several horizons, which are designated as follows: (*A*) Neighborhood of Kiau-tshang-pa; (*a*) dark trilobite limestone; (*b*) light gray brachiopod limestone; (*c*) red brachiopod and crinoidal limestone; (*d*) marly coralline limestone between Kiau-tshang-pa and Shomhsuen-yi; (*B*) Remains from the neighborhood of Tshau-tién: (*a*) light-colored, crystalline, oolitic, brachiopod, and crinoidal limestone. Both Ordovician and Silurian faunas are included in these collections, the Ordovician faunas being those of the dark trilobite limestone, and the light gray brachiopod limestone from the neighborhood of Kiau-tschang-pa. The relations of the strata in this locality have been shown by von Richthofen,[1] these two beds being included in the axial portion of an overturned anticline among the lowest strata of the section.

The known faunas of these two Ordovician beds are not large, the following forms being recorded from the dark trilobite limestone:

Asaphus sp.
Calymene sp.
Trinucleus richthofeni n. sp.
Orthis kiautschangpensis n. sp.

None of these forms can be identified among the collections of the recent expedition. The species described as *Orthis kiautschangpensis* seems to be a member of the genus *Plectorthis*, and somewhat resembles the form here described as *P. willisi*, but it is proportionately broader toward the hingeline and has more angular cardinal extremities; two of the genera of trilobites *Asaphus* and *Calymene*, also occur in the recent collections, but *Trinucleus* has not been detected, although this genus would not be out of place in such a fauna as has been recognized.

From the light gray brachiopod limestone the following forms have been recorded:

Orthis calligramma Dalman var.
Leptæna sericea Sowerby
Strophomena corrugatella Davidson ?
Spirifer radiatus Sowerby

Of these species *Orthis calligramma* is one of the most conspicuous members of the faunas described in the present paper from Sü-kia-pa, near Ta-ning, and an undetermined species of *Strophomena* is another one of the common species. *Leptæna*, or, more properly, *Plectambonites sericea*, has not been detected, although it would not be out of place in association with *Dalmanella testudinaria*. The shell referred to *Spirifer radiatus* by Kayser is probably incorrectly determined; the species and even this genus would be entirely out of place in any fauna with *Orthis calligramma* and the other forms recorded, and judging from the illustrations the specimens are too imperfect to permit their certain identification as *Spirifer*. It is not impossible that this so-called *Spirifer radiatus* is allied to the forms described in this paper as *Hemipronites tenuistriatus*, although the two forms are certainly distinct, at least specifically.

[1] China, vol. II, pp. 597–598, fig. 108.

On the whole these Ordovician faunas described by Kayser may be considered as indicating essentially the same geologic horizon as those collected by the more recent expedition, although the relationship is not so close as that between the recent collection and the one from Shen-si described by Martelli. The three localities where this horizon is recognized in northeastern Ssï-ch'uan and southern Shen-si are situated at the angles of a large triangle, each limb of which is from 200 to 300 miles (320 to 480 km.) in length, and it is not improbable that beds belonging to this same general horizon have a somewhat wide geographic distribution in central China.

In correlating the fauna of the Ki-sin-ling limestone collected by the Carnegie Institution of Washington Expedition with the Ordovician faunas of other parts of the world, it is necessary to consider two conspicuous elements, the brachiopods and the trilobites; the remaining portions of the fauna, being unimportant, may be disregarded.

The brachiopods are represented by nine species, two of which have been identified only generically, and of the remaining seven species three are described in the present report as new, and one, from southern Shen-si, has been described by Martelli. The previously known species from other parts of the world are *Orthis calligramma* Dalman, *Dalmanella testudinaria* (Dalman), and *Dalmanella subæquata* (Conrad). The first of these, *Orthis calligramma*, is not recognized as occurring in North America in Schuchert's "Synopsis of American Fossil Brachiopoda," but it is a conspicuous north European species, being recognized in various localities in Great Britain, Sweden, and Russia. In Great Britain Davidson gives the range of the species as through the Llandeilo, Caradoc, Llandovery, and Wenlock formations,[1] the greater number of specimens he has illustrated being from the Caradoc. The Chinese examples most closely resemble those from Russia illustrated by de Verneuil,[2] whose stratigraphic position is given by that author as "dans les couches les plus profondres de la formation silurienne." The range of the species in the Baltic provinces of Russia, as recorded by various more recent authors, seems to be from the upper portion of the Glauconite limestone to the Jewe beds. The second of these species, *D. testudinaria*, has a wide geographic distribution and has been recognized in many localities in North America and Europe. The species ranges throughout the middle and upper Ordovician. The third species, *D. subæquata*, is a North American form which has not been recorded from Europe, and the Chinese specimens agree in all essential details with North American examples. In North America the species is highly characteristic of the lower portion of the middle or Mohawkian division of the Ordovician, being especially abundant in the Black River or in faunas of equivalent age.

The species of brachiopods described as new in this report, with the one described by Martelli from Shen-si, belong to the genera *Triplecia*, *Plectorthis*, *Clitambonites*, and *Hemipronites*. The genus *Triplecia* occurs in North

[1]Monog. Brit. Sil. Brach., p. 245. [2]Geol. Russia and Ural Mts., vol. II, p. 207, plate 13, figs. 7 *a–f*.

America, although it is apparently an immigrant in our faunas. The Chinese species *T. poloi*, however, is of the typical American form of the genus, being more or less remotely related to *T. extans* Emmrich of the Trenton limestone. The range of the genus in North American faunas is from the lower Ordovician or Canadian to the Niagaran division of the Silurian. *Plectorthis* is a widespread genus in the Ordovician faunas of both North America and Europe. *Clitambonites* occurs rarely in the middle Ordovician or Mohawkian faunas of North America and more commonly in the European faunas, its relationships are European rather than American, and *Hemipronites* is strictly a European genus. Both of these two last genera have their greatest development in the faunas of the Baltic provinces of Russia, where they occur in the Glauconite and Vaginatus limestones associated with *Orthis calligramma*. The genus *Strophomena*, which occurs abundantly in the Chinese fauna, although the species has not been identified, is a much more conspicuous member of the North American Ordovician faunas than those of Europe, although it is not uncommon in Europe.

Among the trilobites the most conspicuous feature in the Chinese fauna is the great variety of Asaphidæ belonging to the genera *Asaphus*, *Megalaspis*, and *Isotelus*. Another notable faunal character is the presence of the genus *Ampyx*. Although none of the species of these genera of trilobites has been certainly identified with previously known forms, the complexion of the whole assemblage is strongly suggestive of the same Ordovician faunas of the Baltic provinces of Russia that are characterized by the brachiopods *Hemipronites*, *Clitambonites*, and *Orthis calligramma*. The genus *Isotelus* is conspicuous in the North American faunas, but *Asaphus* proper and *Megalaspis* do not occur. Among the Chinese species *Asaphus blackwelderi* and the pygidia compared with *Asaphus expansus* Dalman are of first importance. In Russia *Asaphus expansus*, which is certainly a close ally of these Chinese forms, is particularly characteristic of the Glauconite limestone, and it occurs also in Scandinavia at a similar horizon. The species here described as *Ampyx chinensis* is closely allied to *A. nasutus* Dalman, which occurs in both the Glauconite and *Vaginatus* limestones of the Baltic provinces of Russia and in limestones of similar age in Scandinavia. *Ampyx costatus* Boeck, with which one of the Chinese species is compared, occurs in the *Echinosphærites* limestone of the Baltic provinces, the formation superjacent to the *Vaginatus* limestone.

The single form of cephalopod from the Ki-sin-ling limestone has been referred to the genus *Vaginoceras*. In America the described species of this genus occur in the Black River limestone. In the Baltic provinces of Russia the genus is represented by the *Orthoceras vaginatum*, whose great abundance has given name to one of the Ordovician formations of that region, the *Vaginatus* limestone, sometimes also called the *Orthoceras* limestone.

The above analysis of the Chinese fauna described in this paper shows clearly its strong relationship with the north European Ordovician faunas, and especially with the fauna of the Glauconite and *Vaginoceras* limestones

of the Baltic provinces of Russia. These two formations are essentially equivalents of American faunas included in the Mohawkian division of the Ordovician, and we recognize in this Chinese fauna several species among the brachiopods which are identical with or closely allied to North American Mohawkian forms. The fauna presents in its entirety a mingling of Baltic and North American forms, although the Baltic element is much the more pronounced. In age the fauna is clearly not younger than the Mohawkian faunas of North America, and it may be safely considered as the essential time equivalent of the Black River limestone of North America and of the *Vaginatus* limestone of Russia.

Explanation of Plate 25.

1– 2. *Strophomena* sp. undt. Weller (p. 281).
3– 6. *Orthis calligramma* Dalman (p. 282).
7– 9. *Triplecia poloi* (Martelli) (p. 281).
10–11. *Plectorthis willisi* Weller (p. 283).
12–16. *Dalmanites testudinaria* (Dalman) (p. 283).
17–18. *Clitambonites chinensis* Weller (p. 283).
19–20. *Dalmanella subæquata* (Conrad) (p. 283).
21–24. *Hemipronites tenuistriata* Weller (p. 284).

Explanation of Plate 26.

1. *Cornulites* sp. undt. Weller (p. 285).
2. *Crytodonta* ? sp. undt. Weller (p. 285).
3–4. *Asaphus* sp. cf. *A. expansus* Dalman (p. 287).
5. *Asaphus asiaticus* Weller (p. 287).
6. *Asaphus lævis* Weller (p. 287).
7. *Asaphus chinensis* Weller (p. 287).
8. *Megalaspis minor* Weller (p. 288).
9. *Asaphus* sp. undt. Weller (p. 288).
10. *Illœnus ? bronteoides* Weller (p. 289)
11. *Proetus?* sp. undt. Weller (p. 289).
12. *Pterygometopus* ? sp. undt. Weller (p. 289).
13. *Isotelus* ? sp. undt. Weller (p.288).
14. *Asaphus* sp. undt. Weller (p. 288).
15. *Isotelus* sp. undt. Weller (p. 288).
16. *Ampyx chinensis* Weller (p. 285).
17–18. *Bathyurus* sp. undt. Weller (p. 285).
19–20. *Asaphus taningensis* Weller (p. 286).
21–22. *Asaphus blackwelderi* Weller (p. 286).

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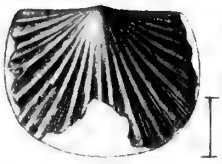

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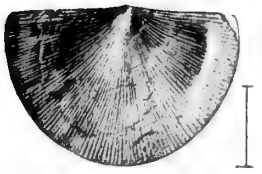

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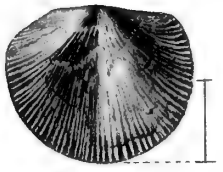

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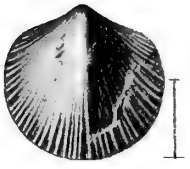

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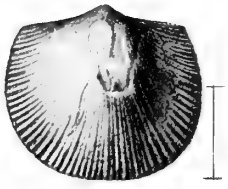

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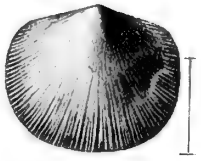

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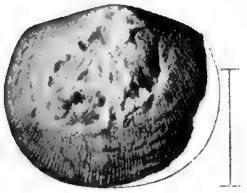

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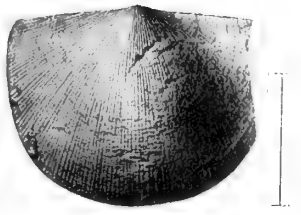

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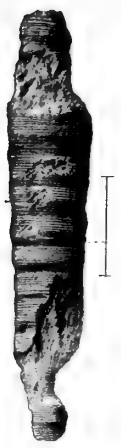
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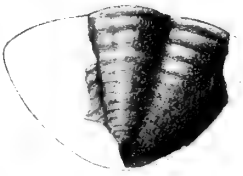
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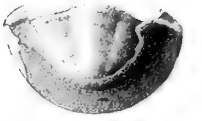
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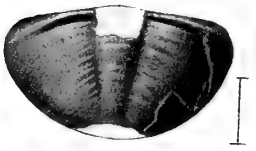
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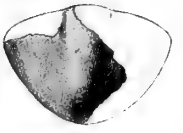
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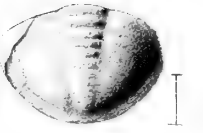
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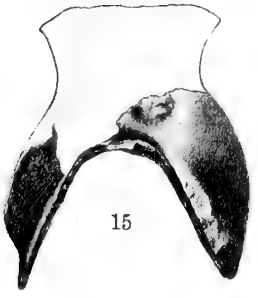
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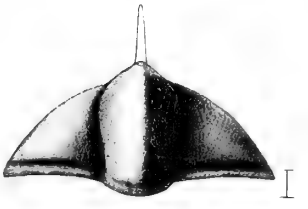
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COCKAYNE—BOSTON

A REPORT ON UPPER PALEOZOIC FOSSILS COLLECTED IN CHINA IN 1903-04.

By George H. Girty.

A REPORT ON UPPER PALEOZOIC FOSSILS COLLECTED IN CHINA IN 1903-04.

GENERAL REMARKS AND CONCLUSIONS.

The upper Paleozoic collections from China, collected by the Carnegie Institution of Washington Expedition, which I have had the honor of examining comprise fourteen lots, of which the geographic distribution is as follows: From the province of Shan-tung two lots (59 and 69); from the province of Shan-si one lot (20); and from East Ssï-ch'uan eleven lots (1, 2, 3, 4, 5, 6, 7, 8, 9, 16, and 17).

The material from East Ssï-ch'uan, which thus comprises practically all the collections, may again be subdivided according to stratigraphic occurrence along lines which are so coincident with faunal peculiarities that a number of smaller groups are formed, each of which is entirely distinct from the others and from the equally disconnected collections from the other provinces.

The lowest horizon in the Ssï-ch'uan section is represented by lots 6, 8, and 9, obtained near Ta-miau-ssï. The next horizon above is found in lots 1, 2, 3, and 4, collected near Ta-ning-hién, and by lot 7, collected near Liang-ho-k'óu. Lot 7 contains only one species in common with lots 1, 2, 3, and 4, but this is not surprising, in view of the fact that the whole number obtained is small. By reference to the table on page 304 it will be seen that the fauna of lots 1, 2, 3, 4, and 7 contains nothing in common with those of the first group, except the presence of crinoidal fragments.

The next horizon is represented by one collection (17) of three species, none of which occurs in the beds below. The succeeding horizon also is represented by one collection (16), with two citations, neither of which was obtained elsewhere. The topmost formation, the K'ui-chóu series, is likewise represented by one collection (lot 5), containing three citations, and is unconnected with the faunas below, the only resemblance indicated by the table being some indeterminable pelecypod fragments.

From the province of Shan-si we have one collection (lot 20) of three species, one of which appears to be the same as a form obtained in East Ssï-ch'uan (*Hemiptychina ?* aff. *H. orientalis*, from station 7). The specific characters in one case, however, have been destroyed, and the union of the two occurrences is rather an expression of the fact that there is no ground for separating them than that the evidence assigns them to the same species.

From Shan-tung our collections contain two lots (59 and 69), which have no determinable species in common. Although they contain two citations which occur in the other lists, the material is poorly preserved, and the community of reference in this case, as in the other, is an expression of the absence of negative rather than the presence of positive evidence.

The Carboniferous faunas of China, and indeed of eastern Asia generally are but scantily known. The stations from which collections have been obtained often lie at widely distant intervals and the collections themselves have often been meager. A notable exception must of course be made in favor of the splendid collections upon which was based Waagen's monograph upon the fauna of the *Productus* limestone of the Salt Range.[1] Very considerable also were some of the collections which furnished the data for Diener's accounts of the Carboniferous faunas of the Himalaya.[2] The Carboniferous faunas of Turkestan which Romanowsky described[3] were, however, for the most part both scanty and poorly preserved. Several writers have reported upon Carboniferous faunas from the Indian Archipelago: Beyrich in 1865,[4] on fossils from the island of Timor; Martin in 1881,[5] also from Timor; Rothpletz in 1892,[6] upon essentially the same fauna; Roemer in 1880,[7] upon fossils from the west coast of Sumatra; and Fliegel, upon the same fauna, in 1901.[8]

In the case of China itself we have the well-known account of Kayser[9] upon fossils collected by von Richthofen, chiefly from the single locality at Lo-ping. Loczy has recently described[10] a number of faunas from different stations and different horizons, none of them of very great extent. Frech also has discussed[11] a few local faunas in a rather cursory way. Professor Fuetterer is reported to have obtained extensive paleontological collections in eastern Asia, and treatises upon them appear to have been recently published, or are about to be published forthwith, but I have been unable to secure copies of such works, if they have been issued. Finally, Tschernyschew has given a list of Carboniferous fossils obtained near Vladivostock.[12]

It would perhaps be expected that the faunas of the present collection would prove to be identical with those of the reports mentioned, but this does not seem to be the case. Some of them are, to be sure, so limited as to be scarcely adequate for paleontologic correlation. In a case to be mentioned later there seem to be reasons of a geologic and geographic nature for believing that one of them was obtained from the same horizon as one of the local faunas reported by Frech, but the intrinsic evidence, while rather favorable than otherwise to this correlation, based upon other data, was by no means such as to establish it independently.

In considering the geologic age of these faunas it will be better to begin

[1] Mem. Geol. Surv. India, ser. 13, Salt Range Fossils, vol. 1, 1887.
[2] Mem. Geol. Surv. India, ser. 15, Himalayan Fossils, vol. 1, pt. 2, 1899; pt. 3, 1897; pt. 4, 1897; pt. 5, 1903.
[3] Materialen zur Geologie von Turkestan, St. Petersburg, 1880.
[4] Abhand. Kön. Akad. Wissensch. Berlin, 1865, pp. 61–100, plates 1–3.
[5] Sammlungen des Geologischen Reichs-Museums in Leiden, I, Beiträge zur Geologie Ost-Asiens und Australiens, Leiden, 1881, pp. 1–64, plate 1–3.
[6] Paleontographica, vol. 39, 1892, pp. 57–106, plates 9–10.
[7] Paleontographica, vol. 27, 1880, pp. 1–11, plates 1–3.
[8] Paleontographica, vol. 48, 1901, pp. 91–136, plates 6–8.
[9] Richthofen's China, vol. 4, Berlin, 1883.
[10] Wissenschaftliche Ergebnisse der Reise des Grafen Béla Széchenyi in Ostasien, Bd. 3, 1898, pp. 41–132, with plates.
[11] Neues Jahrbuch für Mineralogie, Geologie, und Palaeontologie, vol. 2, 1895, p. 47; Ueber palaeozoische Saunen aus Asien und Nord Africa.
[12] Bull. Comité Géologique, St. Petersbourg, 1889, No. 22, pp. 353–359.

in the Ssï-ch'uan section with that which is next to the lowest, represented by lots 1, 2, 3, 4, and 7. This fauna, containing as it does *Schwagerina* and *Notothyris*, is clearly Upper Carboniferous, and well up.

The three overlying faunas are too scanty to determine their age very definitely. The greatest doubt surrounds the highest of these, that which was found in a gray limestone lying upon the Red Beds 7 miles (11.2 km.) south of Ta-ning-hién. From this horizon our collection affords only round crinoid stems, *Dielasma ?* cf. *D. elongatum*, *Aviculipecten ? richthofeni* Girty, and indeterminable fragments of pelecypods.

The little pectinoid described as *Aviculipecten ? richthofeni* is of a type which is common in the Paleozoic, and doubtless in the Mesozoic as well. It has a somewhat related species in the Permian of Russia (*Avicula kazanensis* de Verneuil). The cardinal structures, and therefore the generic position, can not be ascertained from our material. The terebratuloid cited as *Dielasma ?* cf. *D. elongatum* has two large dental plates, but the structures of the dorsal valve, which are usually more difficult to ascertain, have not been satisfactorily determined. I believe that it is not definitely known to what extent Mesozoic terebratuloids develop plates in the ventral valve, but it appears to be rather a peculiarity of Paleozoic shells. Upon this point Waagen says, speaking of *Hemiptychina:* "The genus is distinguished very characteristically from the greater number of Paleozoic Terebratulæ by the absence of dental plates in the ventral valve. In this respect it approaches more closely to Mesozoic forms, in which dental plates are nearly always absent." [Mem. Geol. Surv. India, Palæontologia Indica, Salt Range Fossils, vol. 1, p. 361.] It would appear from this that this type of structure is more common in the Paleozoic, though not entirely confined to faunas of that period.

The evidence upon which the horizon in question is referred to the Paleozoic consists of the septiferous terebratuloid, the round crinoid stems, and the general Paleozoic complexion of the meager fauna. It is inconclusive and may not stand against any facts which strongly point to a Mesozoic age. For this reason my assignment to the Carboniferous is provisional merely, and should the necessity arise of changing to a younger period the readjustment would entail no serious conflict of evidence.

The fauna from Yön-yi-ssï, in Shan-si (lot 20), is very scanty and the only significant species is the crushed terebratuloid which, if correctly identified as a *Hemiptychina*, would warrant placing this horizon also in the Upper Carboniferous.

The collection from station 69, in Shan-tung, I refer to the Upper Carboniferous with some reserve. From this point were obtained the following species:

Chonetes sp.
Marginifera sp.
Squamularia cf. *S. perplexa* McChesney
Cleiothyridina ? sp.

From the same vicinity and at about the same horizon von Richthofen made a collection which Frech listed in the following terms:

PO-SHAN.

Spirifer bisulcatus Sowerby
Spirifer duplicicosta Phillips
Spirifer (Martinia) glaber Martin
Productus semireticulatus Fleming
Productus punctatus Sowerby
Productus humboldti d'Orbigny
Productus sublævis De Koninck?
Productus longispinus Sowerby
Productus granulosus Phillips
Bellerophon hiulcus Sowerby ?
Loxonema walciodorense De Koninck
Macrocheilus cf. *intermedius* De Koninck
Phymatifer pugilis Phillips
Naticopsis cf. *globulina* De Koninck
Orthoceras sp.
Crinoid stems.

From Hei-shan, in the same general region, the following closely related fauna was obtained:

Spirifer duplicicosta Phillips
Spirifer bisulcatus Sowerby
Orthothetes crenistria Phillips
Productus giganteus Martin
Productus semireticulatus Fleming
Productus humboldti d'Orbigny
Productus longispinus Sowerby
Macrocheilus cf. *intermedius* De Koninck

I see no reason for doubting the evidence which tends to correlate the fauna from station 69 with that obtained by von Richthofen from Po-shan, although they have very few species in common. Yet Frech calls this horizon Lower Carboniferous (Mountain limestone). My fauna presents but few facts of real evidence upon this point, and I will dismiss everything except the form which resembles *Squamularia perplexa* McChesney of the American Coal Measures. As the result of a great many observations of my own and some which are recorded in literature, I am tentatively accepting the generalization that the early Carboniferous Reticulariæ possess strong dental plates and a median septum, while the later ones (*Squamularia*) were without any sort of septal structures. More specifically, in our own section the Mississippian forms possess internal plates and the Pennsylvanian ones do not. Now, the Chinese fossils from station 69, so far as can be ascertained, are without these internal structures. On this account especially, but also because the fauna has more or less of a Pennsylvanian facies and lacks anything distinctively Lower Carboniferous, I feel myself unable to correlate the Shantung collection with our Mississippian. In this difference from Doctor Frech in regard to the age of this horizon I suppose it is possible that he may be wrong and that the real age is Upper Carboniferous. In this connection the fact should be noticed that the diagnostic form *Productus giganteus* appears only in the lot collected at Hei-shan, and that it is represented only by a fragment. Another point which may not be without significance is that these faunas occur associated with coal beds. On the other hand, I very freely admit that my own determination may be wrong.

But there is still a third possibility—that both determinations are right and that we are merely using terms in different senses. If I understand correctly, Frech would place this horizon in the Mountain limestone of European standards; but while the Mountain limestone is usually correlated with our Mississippian, it is possible that the upper beds of the Mountain limestone may overlap upon our Pennsylvanian. On the other hand, in applying the term "Upper Carboniferous" to this fauna I am using it not

as do the Russians, who thus designate the Gschelian stage of their section, but as our own geologists, so that it would cover the Moskovian as well.

The fauna obtained in Shan-tung at station 59, while quite different from that which occasioned the foregoing remarks, is nevertheless clearly of Upper Carboniferous age.

Probably no group of shells is so characteristic of Carboniferous faunas as a whole, none represented by such a variety of species, and none present in such profusion of numbers as the genus *Productus*. It is therefore one of the most marked peculiarities of these Chinese faunas that shells of this group together with a few *Chonetes* are practically absent. In the Ssï-chu'an section only one form, doubtfully referred to *Productus*, has been found, and but a single small species, probably a *Marginifera*, has come to hand from the province of Shan-tung. With these inconsiderable exceptions the whole family of the Productidæ is unrepresented in our collections.

It is doubtless in part owing to this circumstance that these Chinese faunas present so individual a facies, being, so far as their characters are shown, distinct from any of the faunas with which they would most reasonably be expected to agree. It is true, however, that with the exception of the fauna obtained from the lower beds of the Wu-shan limestone too few species have been procured, and these too obscure and ill-preserved to afford a practical idea of the faunal facies. Whether they be compared with other Chinese Carboniferous faunas described by Kayser, with the faunas of the Salt Range of India, or with those of eastern Russia, it is clear that they are more or less completely different. The lower fauna of the Wu-shan limestone, to which these remarks must especially refer, does, however, show remote affinities with the Indian and Russian faunas, manifested rather in the presence of the same genera than of identical species. Thus, the Wu-shan fauna possesses a stromatoporoid coral, the appearance of which group is such a novel feature in the Salt Range fauna; it has a *Geinitzella* related to *G. columnaris*, together with brachiopods of the genera *Hemiptychina* and *Notothyris*. On essentially the same grounds a certain affinity is shown with the Russian faunas of the Upper Carboniferous, and both faunas have in common the presence of shells belonging to *Schwagerina*, a circumstance in some measure suggesting a correlation with Tschernyschew's *Schwagerina* zone, which, indeed, a few specific resemblances tend to confirm. The faunas in the present collections are less closely allied to those previously known from China than to those from the more remote regions just considered. Aside from the occurrence in both of *Schwagerina* they have little in common with the Carboniferous faunas described in von Richthofen's volume, which came chiefly from Lo-ping, in the province of Kiang-si.

The faunas of western North America have, as compared with those of the Mississippi Valley, a distinctly Asiatic facies; but these Chinese faunas are still distinct, the very features which ally them to the faunas of India and China and in which their Asiatic affinities chiefly reside, aiding prominently

in showing their alien character to those of even western America. While *Schwagerina* is widely distributed over the far Western States, stromatoporoid corals and brachiopods of the genus *Hemiptychina* are thus far unknown this side of the Pacific. Indeed, a paleontologist approaching these faunas with a knowledge only of the American ones, and finding there a *Michelinia* much resembling a species of *Favosites*, a stromatoporoid coral, a *Spirifer* having the general aspect of certain Silurian forms (a type certainly exceedingly rare in the Upper Carboniferous, even if it has elsewhere been found at all at that horizon), conjoined with a practically complete absence of productoid shells, might, on a superficial examination, be widely misled as to their real age, although such a misapprehension could not survive a deeper study.

Kayser thought he saw in his fossils from Lo-ping a resemblance to our American Pennsylvanian fauna, but more critical studies of both have gone far to weaken this supposed relationship. But certain Chinese faunas concerned in this report appear to show resemblances to the Coal Measures faunas of the United States. This resemblance, manifested especially in lots 7, 17, 21, and 69, is probably produced by the small number of the species obtained and by the presence of forms which have a long range and a wide distribution. Whether this apparent resemblance has any real significance must be determined by a better knowledge of the Chinese faunas.

As the presence in the Wu-shan limestone of shells belonging to the foraminiferal genus *Schwagerina* contains a certain suggestion that it represents Tschernyschew's *Schwagerina* zone of the Russian series, which underlies the typical Permian, there might in this fact be found some evidence for assigning the K'ui-chóu series, which overlies the Wu-shan limestone, to the Permian. Upon this point the fauna thus far obtained from the K'ui-chóu series (lot 5) is almost noncommittal. While the collection from this series is not small, it comprises, aside from crinoidal fragments, only three species—a terebratuloid, a pectinoid, and an indeterminable pelecypod. The terebratuloid is present in profusion, and the fact that the limited fauna is not due to scarcity of life or scantiness of collecting, as in some instances, lends more significance than would otherwise be the case to the faunal change indicated below this series. A correlation of the Wu-shan limestone with the Upper Carboniferous of Russia, except in a general way, would, however, be premature. In Russia the *Schwagerina* zone is found at the top of the section, while in the Wu-shan limestone the known occurrence of the genus is at the base.

It remains to speak of the fauna represented in lots 6, 8, and 9, occurring at the base of the upper Paleozoic section. The matrix in this material is a tough arenaceous limestone. The fossils are mostly small, always exfoliated, very difficult to uncover when only partially exposed, and more or less strongly altered in microscopic structure. Their investigation has been attended with much difficulty, and the conclusions to which it leads are consequently lacking in finality. This fauna and that from the base of the overlying Wu-shan limestone are sufficiently well known to give considerable impor-

tance to the absolute break or change which divides them. It would hardly be warranted, on this evidence alone, to decide that the fauna under consideration is older than the Upper Carboniferous, although I believe this to be the case. On the other hand, the presence of the genus *Spirifer* fixes the age of this fauna as post-Ordovician. It is impossible to state positively, however, whether it is Upper Silurian, Devonian, or Lower Carboniferous. As well-characterized Devonian faunas having nothing in common with this are known in China, the chances are lessened for its being Devonian. The evidence of the Bryozoa is indicative of an age corresponding to the American Mississippian, but the brachiopods are unlike those of any Mississippian fauna known to me. This group of fossils seems to me rather to recall Silurian types, and this impression is in some measure borne out by certain resemblances to Silurian forms from China, especially those from Tshau-tién, figured by Kayser, although it can hardly be claimed that the species are identically the same in a single instance. I may say in this connection that as my own knowledge of the Bryozoa is as yet but slight, I have received valuable advice from Mr. R. S. Bassler, of the United States National Museum, regarding those of the present collection.

I am also a debtor to Mr. Willis and to Mr. Blackwelder for references to literature and for many helpful suggestions, not to mention the interesting collections which I have been privileged to study.

REGISTER OF LOCALITIES.

1. Two miles (3.2 km.) north of Ta-ning-hién, East Ssï-chu'an. In black limestone and calcareous green sandstone at base of the Canyon limestone.
2. Two miles (3.2 km.) more or less north of Ta-ning-hién, East Ssï-chu'an. Bottom of the massive Canyon limestone at contact with the green shales.
3. Two miles (3.2 km.) north of Ta-ning-hién, East Ssï-chu'an. In black limestone and calcareous green sandstone at base of the Canyon limestone.
4. Three and one-half (5.6 km.) miles above Ta-ning-hién, East Ssï-chu'an. In axis of sharp anticline in the Canyon limestone. Near Yen-ch'ang.
5. Seven miles (12.2 km.) south of Ta-ning-hién, East Ssï-chu'an. In gray limestone associated with calcareous shales lying upon the "red beds."
6. Two miles (3.2 km.) below Ta-miau-ssï, East Ssï-chu'an. In crystalline limestone, part of the thick series underlying the anthracite coal measures.
7. One-half mile (0.8 km.) north of Liang-ho-k'ou, East Ssï-chu'an. At contact of the black cherty limestone with the green argillites.
8. Two miles (3.2 km.) more or less below Ta-miau-ssï, East Ssï-chu'an.
9. Two miles (3.2 k.m) below Ta-miau-ssï, East Ssï-chu'an.

16. Ta-ning-hién, East Ssï-chu'an. Near the middle of the thick Carboniferous (?) limestone.
17. Tung-kuan-k'óu, East Ssï-chu'an. Above (?) an anthracite seam in the coal series.
20. Yön-yi-ssï. 20 miles (32 km.) north of Ho-chou, Shan-si. In dark bituminous limestone in the Shan-si (coal) series. Exact horizon unknown. Exposure in the main road one-fourth mile (0.4 km.) north of the village.
59. One mile (1.6 km.) north-northeast of Ts'ai-kia-chuang (Tsing-ko-tschwang), Shantung. Strata resemble Ching-lung limestone. Fossils almost wholly in cherts or on weathered surfaces. In rubble over limestone outcrops 200 yards (182.8 m.) southwest of gneiss contact.
69. One mile (1.6 km.) northwest of Yen-chuang, Shan-tung. Found in limestone block lying upon tailing pile of a deserted coal mine.

Distribution of Carboniferous invertebrate fossils from China collected by the Carnegie Expedition.

	1	2	3	4	5	6	7	8	9	16	17	20	59	69	A. 6, 8, 9	B. 1, 2, 3, 4	B. 7	B. 17	B. 16	B. 20	B. 69	B. 59	C. 5
Clavulina ? sp.													×									×	
Fusulina sp.													×									×	
Schwagerina sp.		×	×													×							
Zaphrentis ? sp.													×									×	
Lonsdaleia chinensis Girty	×	×														×							
Michelinia favositoides Girty			×													×							
Syringopora sp.		×														×							
Carnegiea bassleri Girty							×										×						
Archæocidaris sp.													×									×	
Crinoidal fragments			×		×				×						×	×							×
Geinitzella chinensis Girty	×			×												×							
Batostomella meekana Girty				×												×							
Fistulipora waageniana Girty		×														×							
Fistulipora willisiana Girty						×		×	×						×								
Fistulipora sp.						×			×						×								
Leioclema sp.						×		×							×								
Tæniodictya ? sp.								×							×								
Fenestella sp (*a*)									×						×								
Fenestella sp (*b*)									×						×								
Dalmanella ? sp.						×		×	×						×								
Orthotichia ? sp.			×													×							
Schuchertella ? sp.									×						×								
Derbya sp.							×										×						
Chonetes sp.											×		×	×				×			×	×	
Chonetes aff. C. flemingi Norwood and Pratten												×								×			
Productus ? sp.		×	×				×									×	×						
Marginifera ? sp.														×							×		
Spirifer blackwelderi Girty	×	×														×							
Spirifer sp. (*a*)	×		×																				
Spirifer sp. (*b*)						×		×	×						×								
Spirifer ? sp.						×		×	×						×								
Ambocœlia sp. aff. A. planiconvexa Shumard						×		×	×		×				×			×					
Martinia ? sp.							×										×						
Squamularia ? aff. S. perplexa McChesney														×							×		
Cleiothyris ? sp.											×			×				×			×		
Rhynchonella ? sp.						×		×	×						×								
Dielasma ? cf. D. elongatum Schlotheim					×																		×
Dielasma ? sp.					×																		×
Hemiptychina ? aff. H. orientalis Tschernyschew							×					×	×				×			×		×	
Notothyris willisiana Girty							×										×						
Aviculipecten ? richthofeni Girty					×																		×
Schizodus cf. S. curtus Meek and Worthen										×									×				
Pelecypoda indt.			×		×											×							×
Euomphalus sp.			×													×							
Gastropoda indt.										×			×						×			×	
Phillipsia sp. (*a*)		×														×							
Phillipsia sp. (*b*)													×										×
Proetus ? sp.						×									×								
Ostracoda indt.												×								×			
Bythocypris ? sp.													×									×	
Fish plate ?									×						×								

A, group of pre-Pennsylvanian (?) faunas, East Ssï-ch'uan.
B, groups of Pennsylvanian faunas: 1, 2, 3, 4; 7; 17; 16 from East Ssï-ch'uan; 20 from Shan-si; 69 and 59 from Shan-tung.
C, group of post-Pennsylvanian (?) faunas from East Ssï-ch'uan.

PRE-PENNSYLVANIAN (?) SPECIES.

Fistulipora willisiana Girty.

Plate 28, Figures 1, 2.

Fistulipora willisiana GIRTY, 1907, Proc. U. S. Nat. Mus., vol. XXXIII, p. 41.

This species grows in thin epithecate expansions, occurring in considerable numbers in the limestone of which it appears to constitute a paleontologic feature of some importance. The largest fragment seen measures 15 mm., but the original size may have been considerably greater. The thickness of the typical specimen is but little over 0.5 mm. The growth is irregular and contorted. Maculæ are present, but their size and distribution have not been determined. The zoœcia are quite small; they occur six or seven in a distance of 2 mm., and are situated at intervals of about one or two times their own diameter. A lunarium is well developed. Mesopores are usually large and as a rule separate the zoœcia in single rows. They are about the size of the zoœcia themselves, and in some cases are even larger.

This species is distinguished by its thin lamellate growth and by the small size of the zoœcial tubes.

Locality and Horizon.—Pre-Pennsylvanian (?); near Ta-miau-ssï, East Ssï-ch'uan (stations 6, 8, and 9).

Fistulipora sp.

Associated with the foregoing is another more massive species. The structure has, unfortunately, become so obscure in process of fossilization that it can not be studied by means of thin sections. One colony is 8 mm. thick, and, being fragmentary, measures 12 mm. across.

Locality and Horizon.—Pre-Pennsylvanian (?); near Ta-miau-ssï, East Ssï-ch'uan (stations 6 and 9).

Leioclema sp.

This title is employed for a small, cylindrical, possibly branching bryozoan which occurs in some abundance at stations 6 and 8. The usual diameter is from 2.5 to 3 mm. In the course of fossilization the microscopic structure has been much obscured, so that an accurate determination of the genus is no longer possible. So far as can be made out, however, it seems to belong to *Leioclema* and to be related to the American species *punctatum*.

Locality and Horizon.—Pre-Pennsylvanian (?); near Ta-miau-ssï, East Ssï-ch'uan (stations 6 and 8).

Tæniodictya ? sp.

Of this species our collection affords a mere fragment, the length of which is about 10 mm. and the width, representing about the true dimensions, in the neighborhood of 2 mm. The growth indicated is a parallel-sided frond having a section of compressed elliptical shape. The cells are very small and slightly oval in outline, the long diameter being parallel to the axis. There are about ten longitudinal rows, which are arranged in alternation, so that the apertures are placed quincuncially. The distance between two apertures in diagonal or transverse rows is about the same, approximately equal to an apertural diameter, and it is considerably less than that between two apertures in the same row longitudinally. The interapertural spaces appear to be ornamented with many little raised points.

The foregoing partial description is based altogether upon the external appearance of the specimen. The fragment is so small and the preservation of minute structure at this horizon so imperfect that it did not seem advisable to make thin sections. The internal structure therefore remains unknown, and while the general appearance suggests a member of the genus *Tæniodictya*, it is quite possible that this will not prove its true position.

Locality and Horizon.—Pre-Pennsylvanian (?); near Ta-miau-ssï, East Ssï-ch'uan (station 8).

Fenestella sp. (*a*).

This type is represented by two specimens, only one of which retains sufficient character to furnish data for a description, and upon it the following partial account is based. Only a portion of the frond is preserved, and the non-celliferous face is shown.

The growth is regular, the branches are nearly parallel, and the introduction of new ones takes place at long intervals. In a longitudinal direction about six fenestrules occur in a distance of 5 mm., while transversely there are nine or ten. The fenestrules are subquadrate, from one and a half to two times as long as wide. The branches are about two-thirds as wide as the fenestrules, and the dissepiments are essentially the same size as the branches. The surface is marked by fine, somewhat crowded, rounded, wavy, probably inosculating liræ.

Characters of the celliferous face not ascertained.

Locality and Horizon.—Pre-Pennsylvanian (?); near Ta-miau-ssï, East Ssï-ch'uan (station 9).

Fenestella sp. (*b*).

A single specimen represents this type, but it is too ill preserved to be described or to serve satisfactorily for comparisons, and it has been discriminated from the foregoing chiefly because the mesh appears to be somewhat finer.

Locality and Horizon.—Pre-Pennsylvanian (?); near Ta-miau-ssï, East Ssï-ch'uan (station 9).

Dalmanella ? sp.

Plate 29, Figures 3, 4.

This is a very small species, and, because of the hard, siliceous character of the closely adhering matrix, one rather difficult to study, in spite of its relative abundance. No specimen in the collection which can be referred here has a length of over 6 mm., which appears to be about the maximum reached in this dimension. The transverse diameter is usually a little greater.

The ventral valve is rather strongly convex. In a longitudinal direction the curvature is regular, but transversely considered the greatest flexure occurs medially, so that often a sort of angulation takes place down the center of the shell, the sides being gently convex. The beak is strongly incurved, but projects considerably beyond the well-marked cardinal slopes. The general outline is therefore often somewhat shield-shaped, sometimes subcircular.

The surface is marked by fine, rounded, very distinct radiating liræ, of which, in a specimen 5 mm. long, there are thirty-four, and this seems to represent about the average, though doubtless more or less variation exists in this particular, apparently in the direction of greater fineness. The liræ increase by bifurcation, and certain of them are often irregularly larger than the others.

In the interior this valve is furnished with two relatively large dental plates situated well toward the sides of the beak.

The shape of the dorsal valve is transversely subcircular. The convexity is very low, the beak small, projecting but little beyond the hinge-line. Down the center extends a median sinus, narrow and strong near the beak but widening rapidly and losing in relative depth toward the front. No internal structures have been ascertained for this valve, anything in the nature of plates apparently being absent.

The shell substance is distinctly fibrous, and seems in most cases to be impunctate. The appearance of very fine punctation, which I think I have noted in a few instances, may be illusory.

The real generic relations of this little shell are very obscure. More than anything else it suggests an orthoid of the *Dalmanella* group, with which it agrees both in configuration and in such points of structure, save in the very important one of punctation, as it has been possible to determine. A certain amount of superficial resemblance is manifested with some of the atrypoid brachiopods, especially such as possess numerous fine ribs, as, for instance, certain species of *Cœlospira;* but it is doubtful if the resemblance goes further than similarity of form. The presence of dental plates seems to distinguish it from these spire-bearing shells.

This species presents a superficial resemblance to a little shell from Tshautién which Kayser figures as *Rhynchonella* sp.,[1] and also to another form from the same area which he describes as *Atrypa ? tschautienensis;*[2] but these species are represented as having a low fold and sinus in the dorsal and ventral valves, respectively, while if anything the reverse is the case with the form under consideration. Both the species mentioned are of Silurian age.

Locality and Horizon.—Pre-Pennsylvanian (?); near Ta-miau-ssï, East Ssï-ch'uan (stations 6, 8, and 9).

Schuchertella ? sp.

Plate 29, Figure 9.

This species is represented by a single specimen, of so small size that one must infer either that the species is very diminutive or that the specimen is immature. The width is about 3 mm. and the length about 2 mm. The shape is semicircular, but the outline may perhaps contract somewhat at the hinge. The convexity is low, the surface being nearly flat, and the beak but very slightly prominent. The configuration indicates that it is a dorsal valve with a low cardinal area.

It is impossible to make an exact count of the ribs, which are moderately coarse and angular. They are strongly and somewhat regularly unequal in size, three or four more or less distinct gradations being present. Relatively coarse, strong concentric liræ or crenulations characterize the spaces between the ribs without surmounting them.

The generic position of this little shell can not be certainly determined from the characters shown, but these are in every particular such as are possessed by the group *Schuchertella,* although *Orthotetes, Streptorhynchus,* etc., show the same general features. To attempt a specific identification without a more complete representation of individuals seemed unprofitable, but the unusually coarse concentric crenulations which the shell possesses promise an effective means of specific discrimination.

Locality and Horizon.—Pre-Pennsylvanian (?); near Ta-miau-ssï, East Ssï-ch'uan (station 9).

[1]Richthofen's China, vol. 4, 1883, plate 4, figs. 3–3*c*.
[2]Idem, plate 4, figs. 12, 12*a-d*.

Spirifer sp. (*b*).

Plate 29, Figures 6, 7.

This species is fairly common at certain localities present in our collections, but, the matrix being very hard and tenacious, most of the specimens are exfoliated and fragmentary. On this account, because no part of the material seems fit for figuring, I have refrained from naming what with little doubt is an undescribed species. The following are its characters:

The size is rather small; the largest examples probably attained if not exceeded a width of 23 mm. The shape of the dorsal valve is transverse, the proportion of width to length being about as 2 to 1. The hinge-line is long, the cardinal extremities pointed, and the configuration in every way as in the common types of the genus. The fold is broad, well defined, but low. It is subdivided by a median sulcus, with the result that the plications upon it are two in number and distinctly larger than the lateral plications. The number of the latter has not been determined, but there were probably ten or more upon each side of the fold. All the plications are rounded.

The configuration of the ventral valve of course conforms to that of the dorsal. There is a rather broad sinus containing a single median rib.

The surface is crossed by coarse, strong, radiating liræ, which appear to be somewhat narrower than the intervening channels or striæ. A few concentric markings can be made out, but nothing regular or distinct.

This form resembles in a general way *S. mesicostalis* of the Chemung and *S. biplicatus*, *S. mysticensis*, and *S. bifurcatus* of the Mississippian series of the American section, but is of course specifically distinct from either. In the Upper Carboniferous of North America I know of no analogue. A certain resemblance to *S. strigoplocus* of the Russian Carboniferous exists, especially in the superficial adornment, but otherwise there are wide differences.

From the Silurian of Tshau-tién and other points Kayser has figured a number of Spiriferi related to this which he identifies as *Spirifer elevatus* Dalman. They have a very similar expression and in especial agree in possessing a biplicate fold. A constant and significant difference is the greater number of lateral plications in the form under discussion. Kayser does not describe the sculpture of his Chinese shells, but that of European examples differs from our form in possessing concentric as well as radiating liræ.

Locality and Horizon.—Pre-Pennsylvanian (?); near Ta-miau-ssï, East Ssï-ch'uan (stations 6, 8, and 9).

Spirifer ? sp.

Plate 29, Figure 5.

This form is represented by about 10 specimens, but most of them are fragmentary. The dorsal valve, nearly complete and fairly well preserved, possesses the following characters:

The width is 10 mm., the length about 7 mm. The hinge-line is as wide as any part below, the cardinal angles quadrate, and the shape semicircular. The convexity is rather low and the umbo somewhat inflated. There is a low fold, moderately elevated and well defined above, depressed and ill defined below.

The whole surface is crossed by regular, fine, sharply elevated radii, of which about 7 surmount the fold and about 20 occur on either side. The general appearance of this valve is very suggestive of a *Chonetes*, but it lacks the cardinal spines and the rows of pores or internal pustules found in most *Chonetes* between the liræ, besides possessing a distinct though low fold.

Of the ventral valve, unfortunately, our collections contain only very imperfect examples. The marginal outline was of course the same as that of the other valve. The general shape was apparently conical, strongly sloping backward, and with the apex bent in the same direction. The interior of the valve was furnished with two strong dental plates.

The details of the surface are unknown, but whatever markings were present must have been delicate, as no traces are to be found upon exfoliated specimens.

For the Carboniferous this is a singular type, and unfortunately it is imperfectly known. Among Carboniferous species it has no close allies so far as I have discovered. It is in fact more suggestive of the Cyrtiæ of the Silurian and Devonian, such as *C. cyrtiniiformis* and *C. exporrecta*. Too little is known, however, with regard to the areal structures to say definitely whether it is or is not a *Cyrtia*. In some respects it suggests a diminutive representative of the *disjunctus* group of Spiriferi, but the imperfect definition of the fold and sinus and the equality of the radii negative a close affinity with those forms. In some respects also it is of the general type of our Devonian species *Spirifer hungerfordi*.

Of the Chinese forms figured by Kayser that from the Silurian of Tshau-tién identified as *Spirifer radiatus* possesses the most resemblance. His figures, however, appear to represent a form without lateral plications, and therefore one which can not be identical with typical *S. radiatus*. The resemblance between his figures and my specimens (except in the matter of size) is rather striking, but both forms are so imperfectly known that it may be entirely without significance.

Locality and Horizon.—Pre-Pennsylvanian (?); near Ta-miau-ssï, East Ssï-ch'uan (stations 6, 8, and 9).

Rhynchonella ? sp.

Plate 29, Figure 8.

The little shells included under this title are associated with those referred to as *Dalmanella* ? sp., and although they are tentatively assigned to widely different genera, it is not certain that their relationship may not be rather close. Few if any examples included under the present title attain a length in excess of 6 mm., and the average is less. The width is always greater than the length.

The ventral valve is rather strongly convex in the posterior portion, and sometimes in the anterior. The beak is prominent, pointed, and incurved. There is no well-marked sinus, though sometimes the median portion appears to be depressed. The surface is traversed by from 25 to 30 rigid angular ribs.

The dorsal valve is transversely subelliptical; the beak small and depressed. Perhaps by deeper exfoliation, the posterior portion sometimes has a mesial depression, which, however, soon dies out. Some specimens have an indistinct fold, and the ribs are in number and character as in the ventral valve.

The most typical examples of this division differ from *Dalmanella ?* sp. in lacking the mesial angulation of the ventral valve, instead of which they are regularly rounded transversely, or even in some cases with indication toward the front of a mesial depression. The ribs are coarser, more distinct and angular, and they rarely if ever bifurcate. In the other valve there is little difference in configuration, and a discrimination rests almost wholly upon the character of the ribs, though in some cases the convexity is greater, and there is occasional evidence of a fold, instead of a depression, along the mesial line. In many instances, even in ventral valves, and still more so in dorsals, it is impossible to refer a specimen confidently to one group rather than the other; yet some of the ventrals of the division under consideration have a distinctly rhynchonelloid expression, while in those referred to *Dalmanella ?*

sp. the characters appear to be incompatible with the Rhynchonellidæ and are more suggestive of the orthids. If these little shells could be obtained whole and unexfoliated it would doubtless be possible to determine their specific and generic relations. The treatment of them in this instance does not satisfy me, and doubtless will prove unsatisfactory to others.

This form shows little resemblance to any of the Carboniferous species obtained from China by von Richthofen, but it is rather strikingly similar to two Silurian ones from the mountains of Tshau-tién. One of these Kayser identifies as *Rhynchonella* sp.[1] and the other, with which the resemblance is especially close, he describes as a new species under the title *Atrypa ? tschautienensis*.[2]

While in this, as in other cases, it is impossible not to attach significance to these specific resemblances, they may, since even the generic position of the present forms is a matter of uncertainty, prove entirely illusory.

Locality and Horizon.—Pre-Pennsylvanian (?); near Ta-miau-ssï, East Ssï-ch'uan (stations 6, 8, and 9).

Proetus ? sp.

This form is represented merely by a free cheek. Although in our specimen the facial outline of the suture is broken or obscure, there is little doubt that it is one of the Proetidæ; but further than this it would hardly be safe to go. The length of the genal spine is unusual.

Locality and Horizon.—Pre-Pennsylvanian (?); near Ta-miau-ssï, East Ssï-ch'uan (station 6).

PENNSYLVANIAN SPECIES.

Clavulina ? sp.

In the cherts of station 9 (Shan-tung) are several molds of a small organic body which appears to have been a foraminifer related to *Clavulina*. The general shape is nodose-cylindrical or nodose-conical, the length being from 2 to 2.5 mm.

The most complete example retains the internal molds of some of the chambers, which are seen to have had the shape of disks with rounded edges. The lower part of this specimen is inflated and conical, and consists of probably two alternating series with about five chambers in each. The upper part is in a single series and includes but three chambers. The general appearance therefore resembles the genera *Clavulina* and *Dimorphina*.

Another specimen, somewhat longer and much more slender, has a length of about 2.5 mm. and a diameter of 0.5 mm. One end is terminated by a large cell which appears to have been spherical. The other end appears to have been somewhat swollen and conical, and was perhaps constructed like the corresponding part of the foregoing. Though the number and arrangement of cells can not be made out, there are perhaps seven chambers above the cone, the last of which, as already remarked, is spherical and larger than the rest. The surface is entirely without ornamentation, so far as can be made out.

The generic position of this type is undeterminable from the material at hand, but its presence in the fauna is too important to be passed over entirely without description or comment.

Locality and horizon.—Pennsylvanian; near Ts'ai-kia-chuang, Shan-tung (station 59).

[1]Richthofen's China, vol. 4, 1883, plate 4, figs. 3–3*c*.
[2]Idem, p. 47, plate 4, figs. 12, 12*a–d*.

Fusulina sp.

This species is represented by a silicified specimen embedded in chert, which has been so broken as to expose a nearly true cross-section. The maximum diameter is 4 mm. The volutions are 5 in number. About 35 partitions divide the outer volution, some of which are plicated. The specific relations are clearly undeterminable from the material at hand, but the form is important as indicating the geologic age.

Locality and Horizon.—Pennsylvanian; near Ts'ai-kia-chuang, Shan-tung (station 59).

Schwagerina sp.

This species was obtained at several points, but in view of the profusion with which fusulinoid types are wont to occur it is sparingly represented. The shape is subspherical, the diameter of a large specimen being about 5 mm. and the length somewhat greater. From 30 to 35 septa are developed in the course of one of the outer volutions. The finer structures seem to have been lost in preservation, the original punctation, for instance, having been entirely obscured.

Locality and Horizon.—Pennsylvanian (Wu-shan limestone); near Ta-ning-hién, East Ssï-ch'uan (stations 2 and 3).

Zaphrentis ? sp.

In the cherts of Shan-tung (station 59) was obtained a single specimen of a zaphrentoid coral not determinable as to its generic position. It is small and very gradually tapering, the greatest diameter being probably only a little over 5 mm., while the length appears to have been not much over 10 mm. The calice was deep. The number of septa is not easily counted, but there were about twenty, of equal size, extending nearly or quite to the center. A relatively small amount of dissepimental tissue was developed.

Locality and Horizon.—Pennsylvanian; near Ts'ai-kia-chuang, Shan-tung (station 59).

Lonsdaleia chinensis Girty.

Plate 27, Figures 1-3.

Lonsdaleia chinensis Girty, 1907, Proc. U. S. Nat. Mus., vol. xxxiii, p. 37.

This species occurs in large masses, one fragmentary specimen having a length of 18 mm. and a width somewhat greater. The corallites are irregularly polygonal, so that it is difficult to name an average size, unusual length in one direction being compensated by narrowness in another. Perhaps 8 mm. represents the average in nearly symmetrical corallites.

Our specimens do not separate into constituent cells, but break across the walls. In sections the latter appear to be rather thick, with denticles projecting inward from both sides, and a dense median line.

Structurally each corallite is made up of three zones inclosed within an outer wall. The external zone consists of vesicles without septa, the median of septa and tabulæ, while the center is occupied by a pseudocolumella having a vesicular structure. The outer zone, which is rather thick, is formed by large cysts, which, as usual, present the convex side upward and slope strongly downward toward the center. The inner boundary of this zone is well marked. The septate portion is clearly defined and has a nearly circular shape, irrespective of the asymmetry of the corallite as a whole. This portion is rather constant in size, and in few instances does it attain a diameter of more than 4 mm. The septa, which number from 25

to 27, are irregular. They are often alternately long and short, but in parts of the same corallite may be equal, or in appearance replaced by vesicular tissue. Not infrequently one of the smaller (secondary) septa is seen to bend to one side and to become confluent with a primary one. The interseptal loculi are rather abundantly partitioned by what in cross-sections looks like dissepimental tissue but in reality has more the nature of nearly flat horizontal tabulæ. As previously remarked, the septa are often so contorted that they can not be distinguished from the interseptal plates with which they intersect.

The pseudocolumella, which occupies the central area, is fairly distinct from the surrounding structures and consists of relatively small concentrically arranged cysts, which are nearly vertical in position but with the upper end distinctly inclined toward the center. The ends of the septa reach nearly or quite to the pseudocolumella, and some of them appear to connect with the plates which compose it.

As members of the genus *Lithostrotion*, Lonsdale described and figured a number of Lonsdaleiæ from Uralian Russia, some of which may be related to the form under consideration. Lonsdale discriminated his species upon characters which are not shown in ordinary conditions of preservation, not, for instance, in the Chinese material, and at the same time failed to give precise data regarding features which I was able to ascertain. On this account a satisfactory comparison of the present form with his species can not be made. It seems to be distinct from the American and European types whose descriptions I have seen. No species belonging to the genus has as yet been described from China.

Locality and Horizon.—Pennsylvanian (Wu-shan limestone); near Ta-ning-hién, East Ssï-ch'uan (stations 1 and 2).

Michelinia favositoides Girty.

Plate 29, Figures 1, 2.

Michelinea favositoides GIRTY, 1907, Proc. U. S. Nat. Mus., vol. XXXIII, p. 38.

Of this species our collection contains a single specimen, which presents the following characters:

The shape appears to have been hemispherical, with a flat base and a width greater than the height. The latter dimension is estimated at about 40 mm. and the entire width at about 80 mm. The corallites are rather regular in size and shape, and usually small, few of them attaining a diameter of 2.5 mm. The septa are closely approximate, 11 to 13 occurring in a space of 5 mm. They are on the whole rather regular, but are distinctly convex and not infrequently confluent. Mural pores appear to be present, but, as shown in transverse sections, they are rather rare, and their arrangement has not been determined.

Any statement as to septa depends upon the interpretation of certain appearances in thin sections. The bounding walls are not thick and show a dense median line, which is usually more or less wavy. On either side of the median line is a tolerably thick layer, intermediate in transparency between the material filling the intertabular spaces and that of the median plate. The inner edge of this supplementary wall is rather strongly denticulate, the projections being in some places rather regular and in other portions of the same corallite absent or irregular. Whether these projections are really denticles or are continuous ridges has not been ascertained. The tabulæ show the same degree of transparency as the supplementary wall, the projections of which can apparently with justification be interpreted as pseudosepta, the dense median line being the plane of cleavage separating the truly double-walled corallites. It is hardly possible to count the pseudosepta or to ascertain the average number present.

At first sight one might well feel somewhat doubtful where to place this species, whether in *Favosites* or *Michelinia*, the unusually small size of the corallites certainly suggesting the former genus, as well as the mural pores, which appear to be rather rare. Some support might also be found in the character of the tabulæ, which, if they are somewhat too convex, too irregular, and too confluent for *Favosites*, possess these features in too slight a degree for typical *Michelinia*. On the other hand, the somewhat fluted condition of the median plate, which may be connected with the development of pseudosepta, together with the apparent presence of well-developed pseudosepta themselves, seem to distinguish it structurally from *Favosites*. The range of the latter genus, furthermore, appears to terminate with horizons early in the Mississippian, while the present form is of much later occurrence. *Michelinia*, on the other hand, is already known in Upper Carboniferous and Permian (?) terrains. On this account it has seemed that the form under consideration should be denied to *Favosites* and placed with *Michelinia*.

Kayser figures an unidentified species of *Michelinia* from China which differs from the present one in the much greater size of the corallites. By the same character *Michelinia favositoides* may be distinguished from other members of the genus known to me, even from the small-celled Russian species *M. concinna* Lonsdale.

Locality and Horizon.—Pennsylvanian (Wu-shan limestone); near Ta-ning-hién, East Ssï-ch'uan (station 3).

Syringopora sp.

In our collection this species is represented by a single specimen, which is distinguished from other members of the genus known to me by the very small size of the corallites. These average only about 1 mm. in diameter and many are somewhat smaller. In their relation to one another the corallites vary in distance from being almost in contact to standing three or four times their own diameter apart, or even farther. They show the peculiar stolonal growth characteristic of *Syringopora*, and there can be little doubt that they belong to that genus. Unfortunately, the internal structures have been lost. Where cut in cross-section some examples show only a hollow tube and others are filled by calcite. On this account I do not feel at liberty to introduce a new name for what is probably an undescribed species.

Locality and Horizon.—Pennsylvanian (Wu-shan limestone); near Ta-ning-hién, East Ssï-ch'uan (station 2).

Carnegiea bassleri Girty.

Plate 27, Figures 4, 5.

Carnegia bassleri GIRTY, 1907, Proc. U. S. Nat. Mus., vol. XXXIII, p. 40.

This name is introduced for what appears to be a new genus of stromatoporoid corals. Until Waagen and Wentzel described some forms from the Salt Range of India the known occurrence of this group would have warranted the statement that it passed out of existence before the commencement of Carboniferous time. The discovery of a different but related type in an area so close geographically and in strata of such similar age as are those of India and China, is thus deprived of most of its surprise. The Chinese form possesses characters which forbid joining it with any of the established genera whose descriptions have been before me, and it represents with little doubt a new genus. On the other hand, as but a single specimen is known, and as in this group more than in many others, the difficulty is great of distinguishing between specific and generic characters without the comparisons

which several generically related species afford, I have adopted the plan of including the genus and species in a single description.

The growth of *Carnegiea bassleri* is in small lenticular masses, having a slight thickness relative to their spread. One example, for instance, has a thickness of but 4 mm. and a diameter of 35 mm. The structure is fine and dense and seems to be entirely without the lamellate appearance which gives this group its name.

In transverse section the cœnosteum is seen to be made up of walls and apertures, both possessing a very irregular and tortuous pattern. The walls are especially vermicular and inosculated, giving off disconnected spurs and dividing the inclosed space into small separate apertures. The entire course of the walls seems to be made up of curves, and the outlines of the apertures are of course correspondingly curvilinear. The walls are relatively thick, and where projecting spurs are given off these often appear to be rounded and enlarged at the disconnected end, as if terminating in a pillar. Similar enlargements can be observed also in other portions of the walls. The zooidal apertures are nearly equal in size and the whole structure seems to be quite regular, but not infrequently several of the apertures are confluent, although the larger one thus formed is so tortuous that it fails to have this appearance in the *tout ensemble* of the section. Astrorhizæ appear to be entirely absent.

In longitudinal section the skeleton is seen to be composed of continuous zooidal tubes and continuous walls, the latter being, as already shown in transverse section, relatively thick. The zooidal tubes are rather closely tabulate and the walls are perforated. The perforations are of unequal sizes and irregular distribution. It is without doubt owing to these interruptions in the radial walls that in cross-section two or more of the zooidal tubes appear to be connected into a single large vermicular one. Sometimes, owing perhaps to the influence of tabulæ and porous developments, the walls in longitudinal section have a nodose appearance, somewhat as in *Stenopora*. Of course the two genera are otherwise widely different and have different affinities.

In the lower part of the cœnosteum the zooidal tubes are narrow and bent inward toward the point of origin, as in colonies of compound corals and bryozoans. In this region the walls are thin and the pores and tabulæ much less plentiful.

This form appears to be but distantly related to those described from the Salt Range of India, and it presents more structural affinities with the older genus *Stromatopora*. From this, however, it is clearly distinguished by the pattern of the apertures and by the absence of astrorhizæ and of latilaminæ. The zooidal tubes and bounding walls are much more continuously and regularly developed, and the walls themselves apparently somewhat different in construction. They appear to be dense, and but for the local thickening, which may represent radial pillars, structureless. *Carnegiea* seems to belong to the Stromatoporidæ, but to be distinctly different from any of the genera at present assigned to that family.

Locality and Horizon.—Pennsylvanian (Wu-shan limestone); near Liang-ho-k'óu, East Ssï-ch'uan (station 7).

Archæocidaris sp.

In the Shan-tung cherts (station 59) a species of *Archæocidaris* occurs, represented by molds of fragments of the characteristic spines. They are of very small size, round in cross-section, about 0.25 mm. in diameter, and covered with relatively large and closely set spinules, which are arranged in about eight longitudinal rows. Those in the same row are about 0.1 mm. apart.

Locality and Horizon.—Pennsylvanian; near Ts'ai-kia-chuang, Shan-tung (station 59).

Geinitzella chinensis Girty.

Plate 28, Figures 9–14.

Geinitzella chinensis GIRTY, 1907, Proc. U. S. Nat. Mus., vol. XXXIII, p. 42.

The growth of this species is dendroid, specimens occurring in long cylindrical trunks, from which in some instances spring smaller branches. All the specimens examined are fragmentary, the largest having a length of 110 mm. They vary much in point of size. The largest yet noted has a diameter of 17 mm., but the average is nearly 15 mm. In some specimens low monticules, more or less distinctly elongated in a transverse direction, form a noticeable feature, which may have been present in all. The mature region, where the cells had a horizontal direction, measures 4 mm. in a large example.

In thin sections the species shows the usual structural variation where different stages of development are examined. From 7 to 8 cells occur in a linear distance of 2 mm. The acanthopores are large, and vary greatly in number and appearance in sections made at different points of the same zoarium. In longitudinal section a few scattered diaphragms occur just before the cells thicken their walls and bend into a horizontal direction.

This species is closely related to *Geinitzella columnaris* Schlotheim, as identified by Waagen and Wentzel in India, but it hardly seems that the Chinese form can be immediately placed with that species. Waagen and Wentzel state that *G. columnaris* rarely attains a size of 5 mm. and that a diameter of but 2 mm. is often met with. The Chinese form is thus seen to be at least three times as large. So far as observed also, it is never incrusting, a mode of growth which the Indian form is said to exhibit. In thin sections, however, the two species are extremely similar. One distinction which appears to exist is that the cells are a little larger in the Chinese form. Waagen and Wentzel do not state this character in their description, and certain discrepancies which appear to exist between different degrees of magnification, said to be represented by their figures, make it impossible to obtain altogether reliable measurements from that source. Apparently *G. columnaris* presents nine or ten cells in 2 mm. The presence or absence of diaphragms is not stated in the text of their description, but none are represented in their figures. The Chinese form certainly possesses diaphragms, and it seems likely that they will also be found in that from India.

With the differences above noted it seems inadvisable to refer the Chinese form to *G. columnaris*, though it is possible that it will prove no more than a variety, better marked, however, than any of the varieties recognized by Waagen and Wentzel.

Locality and Horizon.—Pennsylvanian (Wu-shan limestone); near Ta-ning-hién, East Ssï-ch'uan (stations 1 and 4).

Batostomella meekana Girty.

Plate 29, Figures 6–8.

Batostomella meekana GIRTY, 1907, Proc. U. S. Nat. Mus., vol. XXXIII, p. 43.

This form has not been found free, and the following description has been drawn up from thin sections. It evidently occurs as cylindrical, probably branching, stems, of which some grew to a diameter of 4 mm., while others are only about 3 mm. thick.

The cells are slightly oval in outline, one diameter being a little greater than the other. In the mature region they are separated by intervals about equal to one-half their own diameter, and number about five in 2 mm. longitudinally. The acanthopore-like granules are relatively few, and as a very prevalent rule occur in

single rows between the apertures. On the average about 8 surround each cell, but as they vary greatly in distribution sometimes more (as many as 12 or 13) and sometimes less can be counted. They are also very irregular in point of size, some having a diameter twice or even three or four times as great as others. Often they appear to be in two well-marked grades of size, but sometimes another intermediate grade can be recognized, and it seems likely that there is no absolute classification to which they can be reduced in this respect. While in a general way the large and small granules appear to be regularly distributed, no definite system or arrangement can be made out. In sections longitudinal to the tubes the thickened or mature region is quite shallow, about twice the width of the apertures. The latter, however, here appear of much smaller diameter than in the transverse section, being only about half as wide as the intercellular granuliferous spaces, which therefore present nearly square areas in thin sections cut longitudinally.

This form is structurally very closely related to *Rhombopora lepidodendroides*, but is clearly distinct from that widely distributed American species. Kayser identified *Rhombopora lepidodendroides* in the Lo-ping fauna. From this *Batostomella meekana* seems to be distinct, as it without much question is if the Lo-ping form is correctly identified. Of the two species of *Rhombopora* described by Waagen from India, it may be distinguished from *R. polyporata* by the much smaller number of granules. Though more similar to *R. obliqua* it also differs in several particulars. It is a more robust form. The cells are more nearly circular and apparently of larger size, since, according to Waagen's figure, only about three occur longitudinally in 2 mm. Furthermore, Waagen states that the granules are all of a size in his species, which is conspicuously not the case in the one under consideration.

Locality and Horizon.—Pennsylvanian (Wu-shan limestone); near Ta-ning-hién, East Ssï-ch'uan (station 4).

Fistulipora waageniana Girty.

Plate 28, Figures 3–5.

Fistulipora waageniana GIRTY, 1907, Proc. U. S. Nat. Mus., vol. XXXIII, p. 44.

Of this species our collection contains but one specimen, which displays the following characters: The form is that of a hollow cylinder, the diameter of which is 25 mm., the length of the fragment being 45 mm. The thickness of the zoarium varies somewhat, but has an average of about 5 mm. It can not be determined whether the original shape was incrusting, hollow cylindrical, or solid cylindrical. So far as can be observed, there is no epitheca upon the inner surface, nor is there any flexing of the cells toward a point of origin. From this circumstance it can perhaps be inferred that the original form was a solid cylinder, of which the axial portion, including the immature region of the cells, has by some means been destroyed.

In thin sections the zoœcial tubes are seen to occur about four in the space of 2 mm. Their distribution, however, is quite irregular. They have very thick walls, which in some cases are almost in contact and in others are separated by distances equal to about the inner diameter of the tubes. In the region of maculæ their distance is sometimes two or three times the diameter. The cells are of course nearly circular, and as a rule separated by rather large mesopores in single rows. Near the surface the spongy tissue of the mesopores gives place to solid investment, in which, though the inner portion of the tubes has still a circular section, the outer boundary, more or less clearly shown, is sharply polygonal. A lunarium is as a rule entirely absent, though in rare cases indistinct but certain traces of the structure can be observed. It is also more or less regularly developed in young stages.

Diaphragms are rather few and distant, and they are developed at very irregular intervals. The vesicles observed in longitudinal sections vary greatly in size. As a rule they are but gently convex, the upper and lower surfaces often being nearly flat and parallel.

This species is clearly distinct from American forms of similar geologic age, and also from *F. parasitica*, the only species described by Waagen and Wentzel from the Salt Range. It is also very distinct from *F. tuberosa*, a member of the Lo-ping fauna described by Kayser.

Locality and Horizon.—Pennsylvanian (Wu-shan limestone); near Ta-ning-hién, East Ssï-ch'uan (station 2).

Orthotichia ? sp.

This form is represented by a single specimen, and a very fragmentary one; but the fauna known from this formation is so limited that it should not be left altogether unconsidered, although a specific, and even a definite generic, identification is impossible.

The specimen has a length of 30 mm. and a width of 38 mm., the latter dimension being nearly complete. The total length was probably not short of 40 mm. and may have been 45 mm. The shell is massive, measuring about 5 mm. in thickness in the middle of the transverse break. From the rather high convexity the inference may be drawn that the shell is a dorsal valve. The striation is fine, about 17 liræ being found within a distance of 5 mm. The shell is as usual profusely and finely punctate, and in addition is marked by evenly distributed black points, much larger and much fewer than the punctæ, which are found only along the centers of the liræ. These undoubtedly represent the location of numerous small spines which have been broken and worn away.

From the absence of plications it seems more probable that we have in this specimen an *Orthis*, rather than an *Enteletes*, and from the high convexity that we have an *Orthotichia* or a *Schizophoria* rather than a *Rhipidomella*. The last-mentioned feature, however, is not so marked as to form very strong evidence. Neither Waagen, from India, nor Kayser, from China, has described orthoids similar to this in other respects and equaling it in size. Tschernyschew figures a shell from Russia, however, identified as *Orthotichia morgani* [*morganiana*] Derby, which is semblable. The horizon given in Russia is the *Schwagerina* zone.

Locality and Horizon.—Pennsylvanian (Wu-shan limestone); near Ta-ning-hién, East Ssï-ch'uan (station 3).

Derbya sp.

This form is represented by a mere fragment, but as it is a ventral valve sufficient characters are shown to determine the generic position and some of the specific features.

Unless this dimension is imperfect, the length measures 18 mm., while the width is uncertain. The area appears to be only moderately elevated. The surface is rather coarsely striate, the striæ being broad and the liræ thin and strong. About 9 or 10 of the latter occur in a space of 5 mm. They are more or less regularly unequal and in three series.

The term *Derbya* is here employed only for the division of that genus which Waagen called the *septati*.

Locality and Horizon.—Pennsylvanian (Wu-shan limestone); near Liang-ho-k'óu, East Ssï-ch'uan (station 7).

Chonetes aff. C. flemingi Norwood and Pratten.

Plate 29, Figure 10.

The subject of this description is a single specimen which has a width of 7 mm. and a length of 6 mm. The shape is semicircular, the convexity high, the beak large and projecting, the umbo inflated, and the ears rather large and depressed. The sinus is narrow and obscure. The number of spines is not known. About 11 ribs occur in the space of 2 mm. As the shell is exfoliated the surface details can not be determined. A very small area which is fairly well preserved, however, seems to show that the ribs were narrow and sharp, with relatively wide, rounded interspaces.

This specimen is unusually long for its width, and probably does not show the average dimensions of the species. It much resembles Tschernyschew's figures of *C. flemingi* Norwood and Pratten, especially figure 10 of plate LVI.[1] Typical *C. flemingi* differs in having a more distinct sinus and probably in the character of the surface ornamentation, although only an imperfect comparison is possible.

With the specimens from which the above description was taken occurs another very young example, which possibly may not represent the same species.

Locality and Horizon.—Pennsylvanian; Yön-yi-ssï, Shan-si (station 20).

Chonetes sp.

Plate 29, Figure 11.

Of this species our collection contains four specimens, two from station 69 and two from station 17. Only one specimen from each lot is sufficiently perfect to serve in drawing up a description. The following characters are found in the example from station 17, a ventral valve.

The width is 6 mm. and the length 3.5 mm. The shape is subsemicircular, flattened in front. The convexity is rather low and the umbonal region slightly inflated. The sinus is broad and faint, or possibly absent altogether. The number of cardinal spines is unknown. The ribs come about seven in 2 mm. While quite distinct, they are nevertheless unusually broad and low. There are in addition fine concentric striæ, which are also faint.

The specimen from station 69, likewise a ventral valve, resembles in a general way that just described. The size and configuration are about the same, except that the width is proportionately less. The striation is equally fine, but the ribs appear to be somewhat more strongly elevated. Although it is possible that the two forms do not belong to the same species, the characters shown are not sufficient to warrant their separation. On the other hand, it is possible that the form allied to *C. flemingi* may be specifically the same as the present, the difference of shape, convexity, and surface being the result of individual variation or the effects of preservation, such as, for example, compression. This does not seem to me sufficiently probable, however, to warrant adopting this interpretation.

Under this title also has provisionally been placed a specimen from the cherty beds of Shan-tung (station 59). It shows the mold of the interior of a dorsal valve. The width is only about 3.5 mm. and the length about 2 mm. The cardinal line is equal to the greatest width below, the shape being subsemicircular, somewhat flattened at the sides and front. There are about 20 rows of internal spines, indicating a corresponding number of ribs, the distance between the rows being about as in specimens from station 69. Areas near the cardinal line upon both sides, including in all about one-third the entire surface, are smooth.

[1] Mém. Comité Géologique [Russia], vol. 16, No. 2, 1902.

The characters of the present shells, so far as known, are more like a group of species occurring in the American upper Devonian and lower Mississippian rocks than any which are known to me from the Upper Carboniferous. The peculiarities especially in mind are the low, broadly rounded or angular ribs and the absence of regular, fine, distinct, concentric crenulations; instead of the latter only faint incremental lines appear to be present.

Locality and Horizon.—Pennsylvanian (Wu-shan limestone); Tung-kuan-k'óu, East Ssï-ch'uan (station 17). Pensylvanian: near Ts'ai-kia-chuang, and near Yen-chuang, Shan-tung (stations 59 and 69).

Productus ? sp.

Plate 29, Figures 14, 15.

This unusual form is represented by three specimens, each from a different locality. They show certain differences, which are regarded as being due to age and will be considered below.

The smallest example has a width of 3 mm. and a length somewhat less. The shape is semielliptical, perhaps contracting a little at the hinge. The cardinal angles were probably quadrate. The shell is nearly flat and the only ornamentation consists of fine, sharp concentric wrinkles, of which there are eight. This specimen has the appearance of a very young *Productus*. The concentric wrinkles in their sharpness and regularity somewhat suggest *Leptæna rhomboidalis*, but the fine ribs of that species are not present.

Another example has a width of 9 mm. and a length of about 7 mm. The cardinal angles are quadrate, the hinge-line straight, and the antero-lateral outline regularly rounded. The convexity is low, the ears somewhat flattened, the beak small and depressed. The general shape is that of a young dorsal valve of *Productus*. The surface is marked by regular, fine, strong concentric wrinkles, 15 in number, increasing greatly in size with the dimensions of the shell. Toward the margin fine concentric striæ can be made out. The mesial area is, furthermore, marked by 5 or 6 relatively coarse, somewhat obscure ribs, which are not so strong as the wrinkles with which they decussate. The more rostal portions of this specimen possess the same characters as the small example first considered.

The third example is similar to that just described, except that it is a little larger and the wrinkles are a little coarser.

This shell possesses the general appearance of *Productus*, but the sculpture, when considered closely, is unusual for that genus. Among our American Carboniferous species I recall nothing comparable to it, and of species of foreign description and occurrence but very few. It resembles to some extent *P. plicatilis* Sowerby, which Kayser identifies from Tshau-tién, but differs both from his and from Davidson's figures of that species. A certain amount of similarity can be traced also to *P. undatus* de France and to *P. carringtonensis* Davidson, as these species are recognized by Kayser and figured in his report. But it is not possible to identify my material with either. In point of being without radial ornamentation, except over a differentiated mesial portion, this form suggests *Productus mesolobus* as figured by Davidson from England and by Murchison, de Verneuil, and Keyserling from Russia. If a *Productus* at all it would perhaps belong to the group represented by *P. mesolobus*, though without question belonging to a distinct species.

Although its characters are such as almost certainly to entitle the present form to recognition as a new species, no name has been proposed for it, both because it is imperfectly known and because of the uncertainty which surrounds its generic relations.

Locality and Horizon.—Pennsylvanian (Wu-shan limestone); near Ta-ning-hién (stations 3 and 4) and near Liang-ho-k'óu (station 7), East Ssï-ch'uan.

Marginifera ? sp.

Plate 29, Figures 12, 13.

This species is represented by three specimens, all ventral valves, which, though differing from one another in certain respects, are yet so imperfectly preserved that it seems inadvisable to separate them.

The size is small, the greatest width probably varying from 11 to 15 mm. in different specimens. The shape is subquadrate. The visceral area is somewhat flattened and gives onto the lateral portions rather suddenly. The sinus is faint or absent. The beak appears to be small and to project but little beyond the hinge. The ribs are fine, about six or eight in 3 mm., rounded and moderately strong. They are fainter over the visceral area, especially toward the beak, and over this area they are crossed by equally fine, regular, but not very distinct concentric wrinkles. A few small spines are scattered over the front and sides, and possibly the visceral area, and probably the ears were also similarly supplied.

This poorly characterized type has others similar or identical with it in many Upper Carboniferous faunas. Among those of North America *Marginifera wabashensis* and *M. ingrata* may be mentioned, from the one of which it differs in its smaller size, finer and more distinct ribs, and absence of a sinus, and from the other in being smaller and more finely ribbed. It resembles *Productus longispinus* as identified by Kayser among Chinese specimens, especially the small, or as he calls it the American, variety. His figures show a deeper sinus than there is evidence of in the examples before me. From typical *P. longispinus* the latter are with little doubt distinct. It may be recalled that Waagen concluded that *P. longispinus* is not a *Marginifera*, the characteristic structures of which are certainly found in the American species mentioned.

It can not be determined whether the present form is a *Productus* or a *Marginifera*, but the superficial resemblance is especially with species of the latter group.

Locality and Horizon.—Pennsylvanian, near Yen-chuang, Shan-tung (station 69).

Spirifer blackwelderi Girty.

Plate 29, Figures 16, 17.

Spirifer blackwelderi Girty, 1907, Proc. U. S. Nat. Mus., vol. xxxiii, p. 45.

This form has been obtained at two localities, and occurs in considerable abundance as casts of separate valves. The following characters have been observed:

The shape of the ventral valve is subquadrate. The convexity is high, the beak large, erect, gibbous. The area is well defined, high, and concave. The foramen is large, its width at the base being almost one-third that of the whole area. The cardinal angles are rounded and the cardinal line considerably shorter than the greatest width. A narrow and moderately deep sinus traverses the shell, becoming gradually broader and less well defined toward the front. The sinus is not divided by plications, nor do any ribs mark the sides. On the interior there are two strong dental plates, but no septum.

The dorsal valve is transversely subelliptical in outline. The cardinal extremities are rounded and the hinge-line is shorter than the greatest width. The beak is small and depressed. A moderately high, rather well defined mesial fold passes downward, gradually widening in its course.

The surface lacks ribs either upon the sides or on the fold and sinus, but is marked by very fine radiating striæ.

I know of no Carboniferous species which really requires comparison with the present. In general appearance it suggests a *Reticularia*, such as *R. lineaia*, but the fine continuous liræ can hardly be interpreted as marks left by the spines which characterize that group.

The development of fine subsidiary liræ seems to be a much more common feature in the English Reticulariæ (*vide R. lineata* var. *reticulata*), judging from Davidson's description and figures, than in the American, where it is essentially unknown. We have at least one, though a little known, form possessing this character which was apparently described by Swallow as *Spirigera prouti*. I am not prepared to speak positively as to the internal structure of this type, but dental plates and septa seem to be absent or but slightly developed. In the American Reticulariæ (*R. pseudolineata*, etc.), and I suppose in the European ones, there is a median septum in both valves, while the ventral valve possesses long dental plates as well. The Chinese shell thus differs in structure from the *lineatus* group of Spiriferi, although it shows some points of superficial resemblance.

Spirifer blackwelderi differs from *S. lineatus* as identified by Kayser from Chinese specimens, as well as from any other Chinese species identified or described by him, nor can it be found among the shells described by Waagen from India or by Tschernyschew from Russia. In fact, closer parallels can be drawn with certain Silurian forms, such as *Spirifer radiatus*, than with those usually found in the Carboniferous. In the *radiatus* group, as in *S. blackwelderi*, the ventral valve possesses dental plates, but while socket plates, and sometimes a low septum, are found in the dorsal valve of the former, that of *S. blackwelderi* appears to be without those structures.

Locality and Horizon.—Pennsylvanian (Wu-shan limestone); near Ta-ning-hién, East Ssï-ch'uan (stations 1 and 2).

Spirifer sp. (*a*).

This species also is known only in a fragmentary manner. The width of the largest specimen, which is a ventral valve, is 98 mm. and the length 55 mm., the latter diameter being by far the least complete. The actual width was probably not much over 100 mm. The actual length is very largely a matter for conjecture; probably it was about 75 mm. The area is broad, seemingly almost the full length of the shell, but it appears to be rather narrow. As nearly as can be ascertained it is 15 mm. high at the beak. The sinus is distinct, but shallow and ill defined.

The side presented to the observer is the interior. Part of the exterior has been uncovered, but no ribs or other ornamentation can be discerned. This feature, therefore, seems to be as in *Martinia*, or possibly *Squamularia;* but the broad cardinal line, the shape (which is probably very transverse), and the curvature (which in spite of manifest crushing appears to be low) put a negative to any such association. We must have in this specimen either a *Spirifer* of a novel type or, more probably, one which by attrition or imperfect preservation has lost its proper surface characters. At the same time, if ribs at all well developed were originally present, the loss must have been considerable to have obliterated them altogether, and it would seem to be impossible that had they been grouped in fascicles, as in the *cameratus* type of *Spirifer*, this structure could have been destroyed, fascicles and all.

On the hypothesis that this form originally possessed well-marked ribs it might be compared with several forms found in the Salt Range of India, but hardly with anything yet known from China. The loss of the ribs would be easier to under-

stand, however, in a form in which they are broad and faint, like *Spirifer ufensis* Tschernyschew or, especially, *S. sokolovi* Tschernyschew, both of which occur in the *Schwagerina* limestone of Russia. The present form, however, is considerably larger than any of the species mentioned.

Under this title I have associated some imperfect specimens from the same and other localities, much smaller in certain cases but otherwise similar, so far as can be made out. The determination of their real relationship, however, must await the discovery of more complete material.

Locality and Horizon.—Pennsylvanian (Wu-shan limestone); near Ta-ning-hién, East Ssï-ch'uan (stations 1 and 3).

Ambocœlia sp. aff. A. planiconvexa Shumard.

Of this species our collection contains but a single specimen, a ventral valve somewhat distorted by compression. From umbo to front the length is 6 mm. The width is about 5 mm. or a little over. The shape is subcircular or subquadrate and the sinus is faint or absent. The surface appears to be smooth and without the scars of spines or other ornament. On this account it has seemed necessary to consider this specimen an *Ambocœlia*, instead of a young example of *Squamularia*. The generic reference is nevertheless tentative.

This form, so far as its characters have been ascertained, is very similar to our common American species *A. planiconvexa*. The only difference which is at all noticeable is the apparent faint development or absence of a sinus; but from a single somewhat crushed specimen the inference that this is a normal feature of the species is hardly justified.

Locality and Horizon.—Pennsylvanian (Wu-shan limestone); Tung-kuan-k'óu, East Ssï-ch'uan (station 17).

Martinia ? sp.

This form is represented by a fragmentary dorsal valve, which probably had a complete length of about 15 mm. and a width of but little less. The shape seems to have been broadly ovate, with rather strong convexity. Two distinct but ill-defined radial depressions divide the surface into three portions, of which the central one, or fold, thus well defined, is perhaps a little broader than the two lateral ones.

This shell might be a *Composita* (its exact position is undeterminable) or a member of several related genera, but upon the whole it appears to me rather more probable that it is a *Martinia*. As such it might belong to any one of a number of species, but too few characters are shown to determine definitely upon this point. So far as can be made out it closely resembles *Athyris globularis* as figured by Kayser from Chinese specimens.

Locality and Horizon.—Pennsylvanian (Wu-shan limestone); near Liang-ho-k'óu, East Ssï-ch'uan (station 7).

Squamularia ? aff. S. perplexa McChesney.

This form is represented by five specimens, all from one locality. They are somewhat exfoliated and more or less badly crushed in the black calcareous shale which forms their matrix. While many details can not be made out, resemblance to the common American species *S. perplexa* McChesney is rather strong.

The largest specimen has a length from umbo to front of about 15 mm. The spine-scars are quite large and arranged concentrically in single rows, which are in some specimens rather closely placed but in others are farther apart and separated

by bands of fine concentric striæ, four or five striæ in each band. This may prove a specific or varietal difference among the specimens themselves, which, however, it did not seem wise to enforce here, and it may also constitute a practicable distinction from the American species, in which a similar character is seldom observed. Like the latter, the form under consideration appears to be without septa or dental plates. So far as my observation extends these structures are absent in this group in all species of Upper Carboniferous or Pennsylvanian age, and present in all those which occur in older rocks. This fact appears to me to satisfactorily validate these two divisions as being, if not of generic, at least of subgeneric value, and since McCoy's term *Reticularia* was associated with the septate group, though latterly extended to designate both, I have already proposed to restrict it to the original content. For the nonseptate group I have provisionally employed Gemmellaro's term *Squamularia*, which some European authors, who appear to have examined characteristic examples of that genus, regard as a synonym of *Reticularia*. *Squamularia* is unprovided with internal septa, however, and can not, therefore, be the same as *Reticularia* s. str., and as it is said to be ornamented with continuous projecting lamellæ instead of fimbriæ of spines, bearing about the same relation to the nonseptate Reticulariæ that among athyroids *Athyris* does to *Cleiothyridina*, it seems a little doubtful to me whether precisely the same term should be employed for both.

Locality and Horizon.—Pennsylvanian; near Yen-chuang, Shan-tung (station 69).

Cleiothyridina ? sp.

Two specimens, each from a different locality, represent this group. They possess a general resemblance, but it is far from certain that they belong to the same species.

A specimen from station 69 is transversely ovate, with a length of 10 mm. and a width of about 12 mm. It is probably imperfect, but the shape appears to have been about as described. The beak is small, pointed, and moderately elevated and incurved. The expression of this little shell is distinctly athyroid, and though the surface characters are unknown, it seems probable that it is a *Cleiothyridina*.

The other specimen, which was obtained from station 17 and appears to be a dorsal valve, has a length of 7 mm. and a width slightly greater. It is compressed entirely flat, and the shape is subcircular, the beak being inconspicuous. The surface characters have been lost. A fibrous shell structure gives the semblance of very fine striation, in addition to which delicate concentric lines can be made out. This specimen has somewhat the appearance of an *Orthis*, a resemblance enhanced by the finely striated surface, but its real affinities are probably very different.

It is not deemed advisable to attempt to determine the specific relations of these specimens from material at hand.

Locality and Horizon.—Pennsylvanian (Wu-shan limestone); Tung-kuan-k'óu, East Ssï-ch'uan (station 17). Pennsylvanian; near Yen-chuang, Shan-tung (station 69).

Dielasma ? sp.

This is an internal cast of a small ventral valve which is about twice as long as wide and has a length of only 3 mm. The general shape is subelliptical. Two strong dental plates are shown. There can be little doubt that this shell is a terebratuloid, the only other type possessing claims of consideration being *Composita*. So far as I have been able to ascertain, that genus, which is so abundant in American Carboniferous faunas, is exceedingly rare elsewhere, and would hardly be expected to appear in the present geographic and faunal relations. Furthermore, young Compositæ are usually nearly circular in outline and would hardly have the dental

plates as well developed nor the beak as large as the present example. As the dorsal valve is unknown, the generic position of the Chinese shell can not be completely determined, but it is more probably a *Dielasma* than one of the other related Carboniferous terebratuloids.

Locality and Horizon.—Pennsylvanian; near Ts'ai-kia-chuang, Shan-tung (station 59).

Hemiptychina ? aff. H. orientalis Tschernyschew.

Plate 29, Figure 21.

Of this species our collection contains a specimen which has been somewhat crushed and distorted by compression. The length is 11 mm. and the width 9 mm. The shape is subpentagonal. The widest point is about midway; from there the gently convex cardinal slopes contract posteriorly and the nearly straight sides approach the front in an almost parallel direction. The front is subtruncate, nearly straight across the middle, and somewhat abruptly rounding to meet the sides. The ventral valve possesses a strong, broad sinus, which extends only a short distance back from the margin, and the dorsal valve also seems to possess a faint, narrow sinus in the same region. Owing to the present condition of the specimen, the presence or absence of marginal plications can not be determined, and, indeed, many details, both of configuration and structure, may be obscured.

In the dorsal valve two septa are clearly shown, while a third may probably be inferred from the fact that one of these seems to have a nearly median situation in the valve, which has slipped considerably to one side in relation to its fellow. In the ventral valve no dental plates seem to be present, even upon the side which has suffered but little from crushing, and since these structures are retained in the similarly injured dorsal valve it appears probable that they were really absent. The specimen therefore must be referred to the genus *Hemiptychina*, nor is an unplicated species alien to the genus, for in *H. sublævis* Waagen we have one in which plication is faint or missing. In *H. orientalis* Tschernyschew the folds are large and few, and to this species the present form appears to be more essentially related than to that in which they are more faint but fine.

If the present form does really possess dental plates, then it is without much doubt a *Dielasma* and is related to a number of species in both hemispheres.

In addition to the specimen from which the foregoing description was drawn up, one very fragmentary example from station 20 has been assigned to the same group. Its specific characters have been lost, as the specimen is quite fragmentary; but the apparent absence of dental plates in the ventral valve, which is the only portion retained, would seem to indicate that the genus is *Hemiptychina*.

Locality and Horizon.—Pennsylvanian (Wu-shan limestone); near Liang-ho-k'óu, East Ssï-ch'uan (station 7). Pennsylvanian; Yön-yi-ssï, Shan-si (station 20).

Notothyris willisiana Girty.

Plate 29, Figures 18–20.

Notothyris willisiana Girty, 1907, Proc. U. S. Nat. Mus., vol. xxxiii, p. 46.

Shell small, subspherical. Ventral valve subovate, gibbous, rapidly and rather suddenly contracting at the beak, which is strongly deflected and truncated by a relatively large foramen. Toward the front this valve is marked by a narrow, moderately strong but shallow sinus extending about half the length. There should be other modifications of the mesial portion to correspond with the plications on the accompanying valve, but if present they are obscured in the typical specimen. On each side of the sinus traces of some six or seven ribs are found. Only about

four of these are developed as plications of the shell, the remainder appearing on the margin as denticulations. Even these four, however, are obscure, and decrease in intensity in proportion to their distance from the sinus.

The dorsal valve is subcircular in outline, highly gibbous. The beak is small, pointed, slightly prominent. There is a strong, deep, ill-defined mesial sinus, which projects in front as a sort of linguiform extension corresponding to a deep emargination of the front of the opposite valve. The sinus, which dies out long before reaching the hinge-line, is subdivided by a strong mesial fold, extending about as far from the edge as the sinus itself, and each of the two channels thus formed is apparently again subdivided by an obscure plication limited to the marginal region. On each side of the sinus there are about six plications, shown rather by denticulations at the edge of the shell than by folds upon its surface.

Internal structure unknown. Shell strongly and finely punctate.

As only a single specimen of this form was found it was impracticable to mutilate it for the purpose of ascertaining its internal structures; therefore the generic position of the species is somewhat conjectural. The shell structure and configuration consign it at once to the Terebratulidæ, and in the character last mentioned it much more closely resembles the genera *Notothyris* and *Hemiptychina* than the plicated Dielasmata. It is somewhat uncertain whether this fossil should be regarded as having a dorsal sinus in which a mesial rib has been developed, or a dorsal fold with two deep channels upon its sides; but the former interpretation seems to be more natural. Upon that view the species under consideration would be one of the *antiplicati*, and its generic position would be with *Notothyris* in preference to *Hemiptychina*. On one side of the specimen may be noticed an appearance similar to that often observed in *Dielasma* when fracture or cleavage takes place along the dental plates, but in the present case this may be due to exfoliation of the thick shell. Of course the presence of dental plates would debar this form from *Notothyris* and *Hemiptychina* alike.

In its specific relations this form differs sufficiently from any of the species whose descriptions have come into my hands to make a detailed comparison unnecessary. It is perhaps as near as any to *N. inflata* Waagen and *N. djoulfensis* Abich.

Locality and Horizon.—Pennsylvanian (Wu-shan limestone); near Liang-ho-k'óu, East Ssï-ch'uan (station 7).

Schizodus cf. S. curtus Meek and Worthen.

Plate 29, Figure 27.

This species is represented by three or four specimens preserved as molds of the interior. The shape and dentition are those of *Schizodus*, and the specific characters indicate an affinity with a little shell figured by de Verneuil as *S. rossicus* var. and also with our American species *S. curtus*. The width is 9 mm. and the height somewhat less, about 8 mm. The general shape appears to have been subcircular, but with the posterior portion of the basal outline straightened and with a long posterior truncation directed toward it at something less than a right angle. The beak is not very prominent, but makes a distinct projection in the outline. In some cases the umbonal ridge seems to have been well marked, in others more obscurely marked.

One would hardly venture to identify this form directly with *S. rossicus*, but it is very similar to a specimen figured by de Verneuil under the title of *S. rossicus* var.[1] It differs, however, in having a less transverse shape, a sharper inferior-posterior angle, and a less strongly inclined truncation. Though closely similar to *S. curtus*, it seems to differ from some of Meek's figures in having a less prominent and pro-

[1]Murchison, de Verneuil, and Keyserling, Geology of Russia and the Ural Mountains, vol. 2, 1845, pt. 3, plate 19, fig. 8.

jecting umbo and a less gibbous inferior outline. Since the Chinese specimens are preserved as internal molds it is impossible to make a definite comparison as to convexity, sculpture, etc.

Locality and Horizon.—Pennsylvanian (near middle of Wu-shan limestone); Ta-ning-hién, East Ssï-ch'uan (station 16).

Euomphalus sp.

The collection from one locality contains two fragments of what appears to be a large species of *Euomphalus*, although they may possibly represent an *Omphalotrochus*. They suggest our American species *subquadratus* and *pernodosus*, and possibly, like the latter, may belong to De Koninck's *Phymatifer*, if one chooses to recognize that group of euomphaloids by a distinct name.

Locality and Horizon.—Pennsylvanian (Wu-shan limestone); near Ta-ning-hién, East Ssï-ch'uan (station 3).

Phillipsia sp. (*a*).

Plate 29, Figure 28.

This species is represented by a pygidium which has been slightly crushed at the posterior end, so that the originally subtrigonal shape has been exaggerated, while most of the projecting portions, except toward the front, have been abraded. The greatest width is 15 mm. and the length is 13 mm. For the reasons given above the number of segments can not be counted, but there must have been from 18 to 20 on the axis. The surface ornamentation is probably obscured, for if rows of nodes once covered the surface no trace of them remains.

The general appearance of this pygidium is not unlike *Phillipsia scitula* of the American Coal Measures strata, but the Chinese form is too imperfectly known to allow comparisons with other species.

Locality and Horizon.—Pennsylvanian (Wu-shan limestone); near Ta-ning-hién, East Ssï-ch'uan (station 2).

Phillipsia sp. (*b*).

In the Shan-tung cherts (station 59) was found a single small pygidium preserved as a mold of the inferior side. The surface ornamentation has of course been lost. The shape is elongate, semielliptical, the width and length being approximately equal and about 4 mm. The axis is wide, one-third the entire surface or a little more, and strongly elevated. It contains about 14 annulations, while about 9 can be counted upon each of the lateral portions. There is a wide, smooth border and doublure, which is more obvious around the posterior end, the strong transverse curvature of the pygidium causing it to be much foreshortened at the sides.

It is doubtful if this is the same species as the foregoing. Its small size and different preservation, combined with the geographic difference of occurrence, have made me hesitate to place both under the same caption.

Locality and Horizon.—Pennsylvanian; near Ts'ai-kia-chuang, Shan-tung (station 59).

Bythocypris ? sp.

In the cherts of Shan-tung (station 59) occur a number of casts of small ostracods indeterminable in their present condition. They probably belong to the *Bythocypris* group and comprise several species.

Locality and Horizon.—Pennsylvanian; near Ts'ai-kia-chuang, Shan-tung (station 59).

POST-PENNSYLVANIAN (?) SPECIES.

Dielasma ? cf. D. elongatum Schlotheim.

Plate 29, Figures 22–24.

This form occurs in great abundance at one of the stations where collections were made, and a large number of specimens have passed under examination. It has been found, however, very difficult to secure suitable examples for study, as the rock breaks across the shells as often as around them. In no instance have the two valves been observed in conjunction.

Probably no example of this form attained a length of 15 mm., and the average appears to be shorter—10 mm. The shape is elongate ovate, the greatest width being some distance back from the anterior margin and the ventral beak being long and pointed. The length is considerably greater than the width. The convexity is moderate to rather strong. While there may be a slight sinuation of the anterior margin when the shell is viewed endwise, no well-marked fold and sinus is manifest in the general curvature.

That the terebratuloids from this locality show considerable variation, especially in point of relative breadth and convexity, my examination appears to demonstrate, but not how wide is the variation nor how closely connected are the extremes; for to have uncovered sufficient specimens to reach a well-established conclusion upon these points would have entailed much labor, with relatively uncertain and insignificant result.

The general form of these shells would seem to place them in the group of *Dielasma elongatum*, though they are almost certainly distinct from that species, differing in having the front more produced and strongly rounded. While quite distinct from typical *D. hastatum*, they nevertheless resemble certain figures of that species given by Davidson, especially some which represent small or young examples. The same is true of their relation to typical *D. elongatum*, from which they differ as above noted; yet with varieties which have sometimes been referred to Schlotheim's species, they in some instances show many features in common. This is true of some of Davidson's figures. Waagen illustrates[1] a specimen which is similar to the prevailing Chinese form, but is probably broader and with a less slender elongate beak. Tschernyschew figures[2] two somewhat different types under this title, that represented by his figure 6 of plate II possessing a greater convexity and a less distinctly ovate shape. On plate XI, figures 5, 6, and 7, he shows a form different apparently from the foregoing, different also from at least many Chinese specimens, in being less elongate and more truncated in front. A similar but larger type is shown by his figure 9 of plate IV.

The Chinese form resembles more closely perhaps the type which he figures as *Dielasma bovidens*, although it is smaller and does not possess so marked a flattening of the anterior portion of the ventral valve. In this figure, however, Tschernyschew certainly does not represent a veritable example of *D. bovidens*, still less in figure 4 of plate IV. The Chinese form never, so far as observed, is as narrow as that which Tschernyschew represents as *D. millepunctatum*, being in fact in shape intermediate between that species and *D. bovidens* and in size much smaller than either.

It may be remarked that it has been the practice of American paleontologists to place *D. millepunctatum* in the synonymy of *D. bovidens*, but this is probably a mistake, and Tschernyschew's identification, at least in the case of Hall's species, is far closer to the truth than our own usage.

[1] Mem. India Geol. Surv., Paleontologia Indica, Salt Range Fossils, vol. 1, 1887, plate 25, fig. 10.
[2] Mem. Comité Géol. [Russia], vol. 16, No. 2, 1902.

The generic position of this form is, unfortunately, rather uncertain. The ventral valve possesses, like many of the Paleozoic terebratuloids, two long dental plates. In the dorsal valve the structures shown differ distinctly from those typical of the genus *Dielasma*. Instead of having a heart-shaped plate supported from the bottom of the valve by three septa converging posteriorly, I find only a single septum medianly situated, with a pair of socket plates which are not very long and are close to the postero-lateral margins. This structure has been observed in several dorsal valves, and if it is the true and entire representation of the original condition there can be little doubt that this form can not be placed with *Dielasma*. On the other hand, I would be in much uncertainty as to where properly to refer it. If we may suppose the presence of a small hinge-plate in conjunction with this distinct septum, it seems likely that the form will prove to be a *Harttina*.

Locality and Horizon.—Post-Pennsylvanian (?) (K'ui-chóu series); near Ta-ning-hién, East Ssï-ch'uan (station 5).

Aviculipecten ? richthofeni Girty.

Plate 29, Figures 25, 26.

Aviculipecten ? richthofeni Girty, 1907, Proc. U. S. Nat. Mus., vol. xxxiii, p. 47.

What appears to be the left valve of this species presents the following characters: size small, general shape semielliptical, slightly inclined backward. Length and breadth approximately equal. Hinge-line nearly as broad as the greatest width. Outline somewhat retracted below the ill-defined wings, but spreading again, and with the sides and front broadly rounded.

The surface is marked by angular ribs situated at relatively wide intervals, and the flat interspaces are divided by very fine radiating liræ. New ribs are introduced interstitially, probably by the enlargement of one of the liræ. The whole is crossed by fine, somewhat lamellose, concentric liræ.

A shell supposed to represent the left valve has an outline similar to that of the right, but of course is inclined in an apparently opposite direction. There is no byssal sinus, and the broad wings are undefined. The convexity is a little lower than that of the right valve and the beak is less prominent.

The surface is without ribs or radial marking, and is in fact nearly smooth, showing only delicate, somewhat unequal and irregular concentric lines.

This species is represented in our collections by a number of right valves and only two left valves. All the larger examples of the right valve are imperfect, so that measurements can not be made, but the length indicated is certainly less than 15 mm. The large specimens, so far as can be told, do not differ, except in size, from the smaller ones.

It can not be definitely stated that the flatter and nearly smooth shell here described as the right valve of the species really bore that relation, but the correspondence in size and shape and occurrence in the same beds render this interpretation quite probable. If so, however, it is certain that the form under consideration is not an *Aviculipecten*, since a byssal sinus, which is well developed in that genus, is here inconspicuous or absent.

In shape and sculpture this form recalls to a certain extent some of the Russian species of *Avicula*. *Avicula kazanensis* de Verneuil of the Russian Permian is perhaps the nearest of these, though it is still considerably different. *Avicula elegantula* Stuckenberg of the Gschelian is still more different.

Locality and Horizon.—Post-Pennsylvanian (?) (K'ui-chóu series); near Ta-ning-hién, East Ssï-ch'uan (station 5).

Description of Plate 27.

Lonsdaleia chinensis Girty (p. 311).

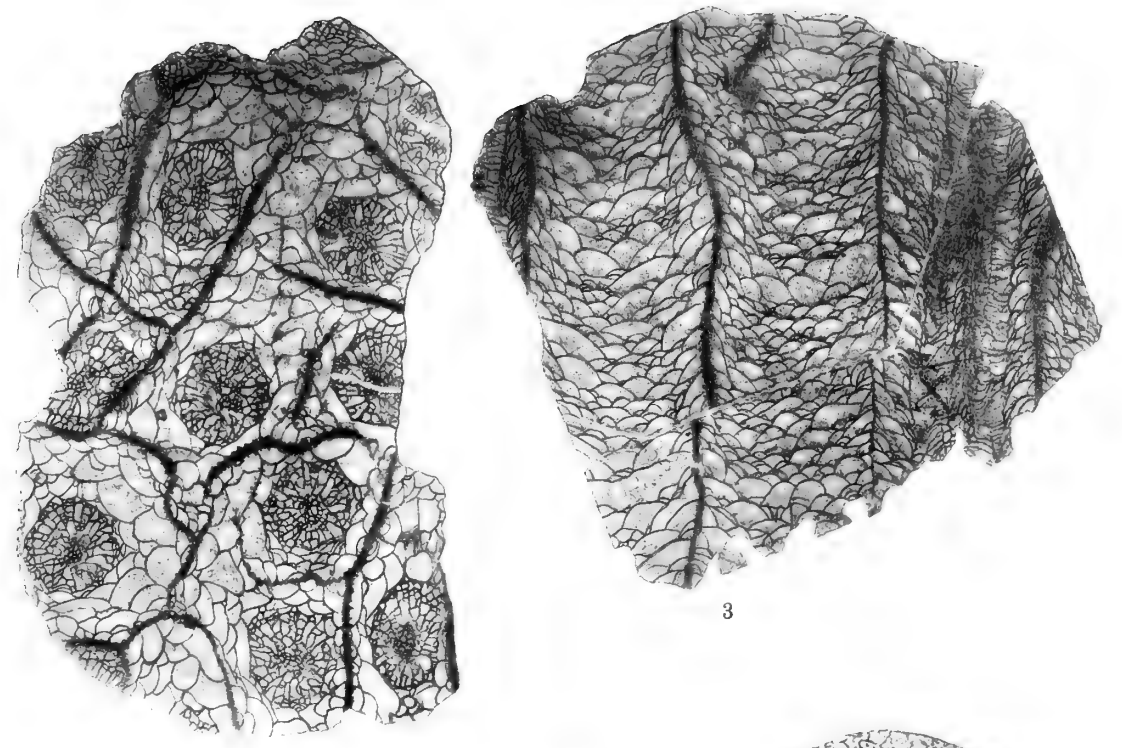
1. Transverse section showing the general structural characters. The fairly constant shape and size of the inner portion of the corallites, as compared with their variable shape and size where taken as a whole, is worthy of notice. ×3.
2. Longitudinal section, × 3. The corallite to the right is cut through its axis and shows well the three structural zones of which it is composed. Laterally, in a much broader band on one side than on the other, are the zones of vesicular tissue, the cysts of various sizes and sloping obliquely downward. In the center is the pseudocolumella, made up of small cysts strongly sloping downward in both directions from the center. Medially on either side of the pseudo-columella is the tabulate zone crossed by closely arranged, more or less horizontal, somewhat irregular and inosculating diaphragms. The two other corallites are cut through the outer vesicular zone.
3. A weathered fragment, natural size.

Pennsylvanian (Wu-shan limestone), near Ta-ning-hién (station 2).

Carnegiea bassleri Girty (p. 313).

4. Transverse section, × 6.
5. Longitudinal section, × 6.

Pennsylvanian (Wu-shan limestone), near Liang-ho-k'óu (station 7).



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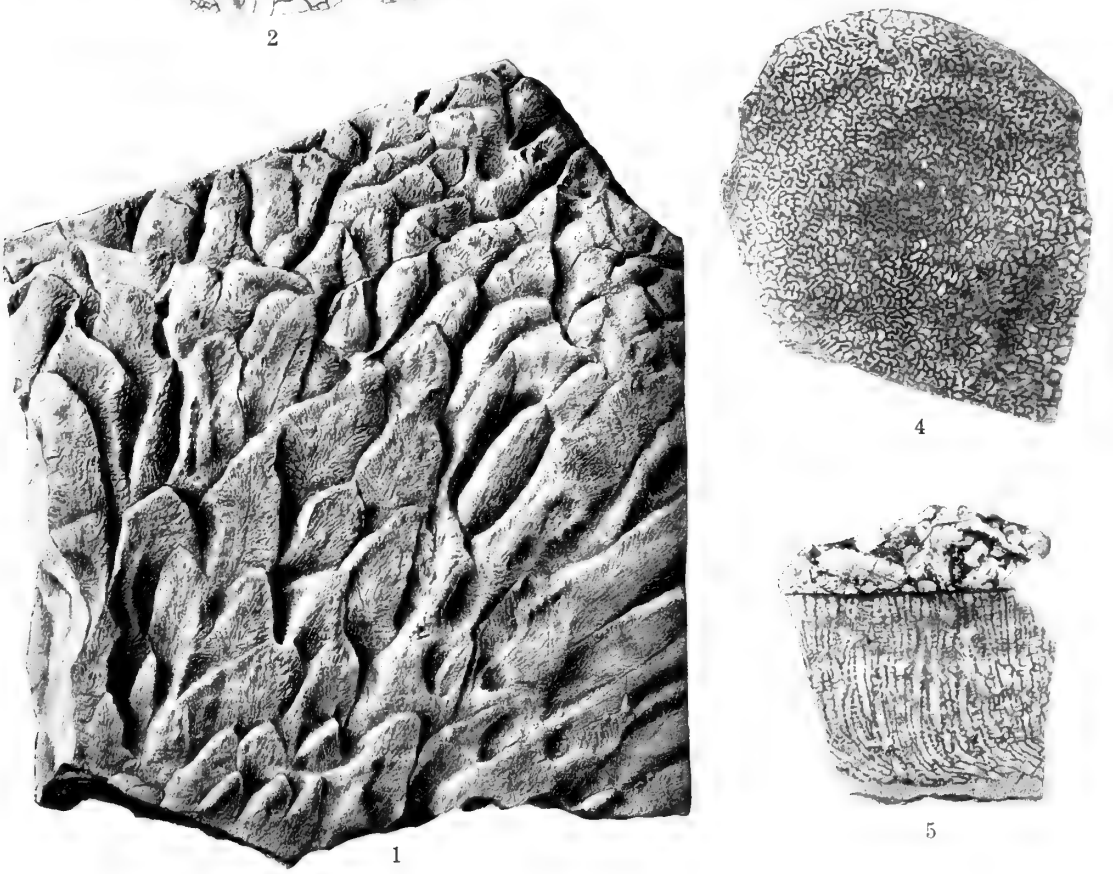

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COCKAYNE—BOSTON

Description of Plate 28.

Fistulipora willisiana Girty (p. 305).

1. Tangential section, × 20.
2. Tangential section, × 35.
   Pre-Pennsylvanian (?), near Ta-miau-ssï (station 8).

Fistulipora waageniana Girty (p. 316).

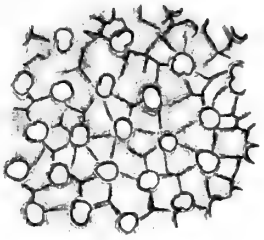
3. Vertical section, × 20.
4. Tangential section through the superficial portion of the mature region where the interzoœcial spaces are filled in with tissue so arranged as to give a polygonal aspect to the cells. × 20.
5. Tangential section, × 20. Usual appearance in the mature region below the outer thickened layer. Here the zoœcia are round, with a distinct investing wall and with small but distinct lunaria.
   Pennsylvanian (Wu-shan limestone), near Ta-ning-hién (station 2).

Batostomella meekana Girty ((p. 315).

6. Tangential section, × 20.
7. Tangential section, × 35.
8. Vertical section, × 35.
   Pennsylvanian (Wu-shan limestone), near Ta-ning-hién (station 4).

Geinitzella chinensis Girty (p. 315).

9. Vertical section, × 20.
10. Tangential section, × 20. The aspect of the walls is shown in the immature and early mature regions.
11. Tangential section, × 35. The acanthopores are large and open, and vary in shape and size.
12. Tangential section, × 20. The acanthopores are seen to be open. The fact that they indent the zoœcial walls betrays their real character as acanthopores instead of mesopores.
13. Tangential section, × 20. A section through the mature region, showing the usual characters.
    Pennsylvanian (Wu-shan limestone), near Ta-ning-hién (station 1).
14. Fragment, natural size, from another locality.
    Pennsylvanian (Wu-shan limestone), near Ta-ning-hién (station 4).



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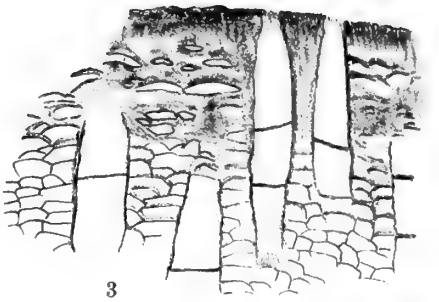

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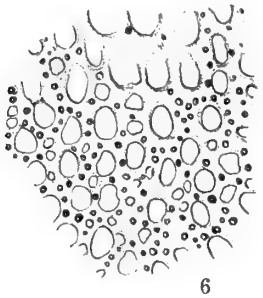

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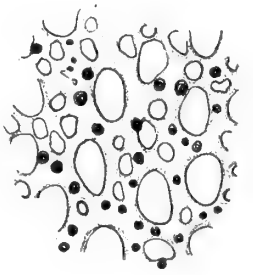

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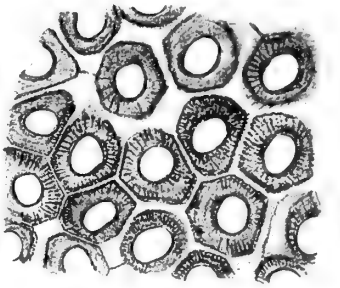

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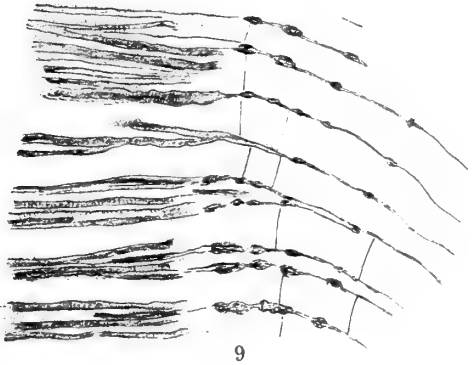

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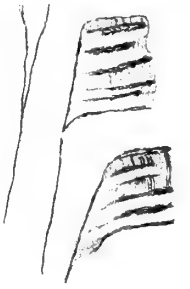

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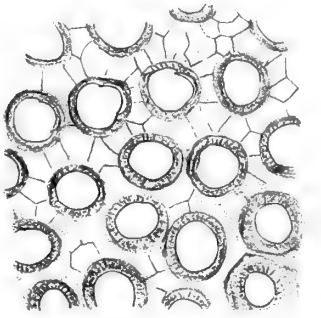

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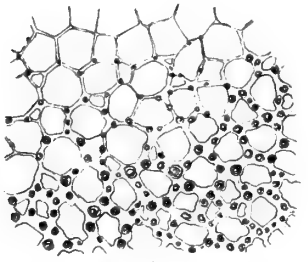

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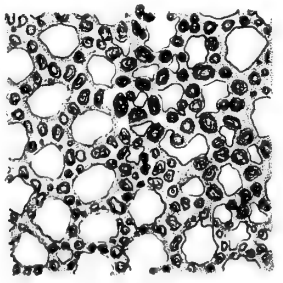

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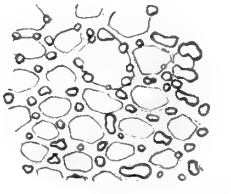

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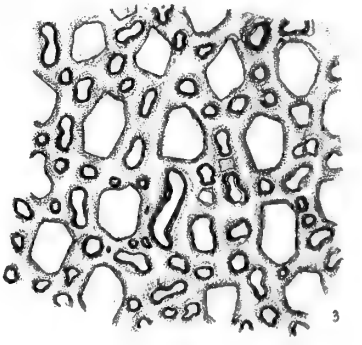

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Description of Plate 29.

Michelinia favositoides Girty (p. 312).

1. A massive corallum, showing the characters in the natural size.
2. Transverse section, × 3. A thin section taken not quite perpendicular to the axis, showing the denticulated walls and the closely arranged tabulæ.
   Pennsylvanian (Wu-shan limestone), near Ta-ning-hién (station 3).

Dalmanella ? sp. Girty (p. 306).

3. Dorsal valve, × 3.
4. Ventral valve, × 3.
   Pre-Pennsylvanian (?), near Ta-miau-ssï (station 9).

Spirifer ? sp. Girty (p. 308).

5. Dorsal valve, × 2.
   Pre-Pennsylvanian (?), near Ta-miau-ssï (station 9).

Spirifer sp. Girty (*b*) (p. 308).

6. Medium-sized dorsal valve, showing biplicate fold.
7. Very young ventral valve in which a fold has not yet begun to develop in the sinus.
   Pre-Pennsylvanian (?), near Ta-miau-ssï (station 8).

Rhynchonella ? sp. Girty (p. 309).

8. Dorsal valve, × 2.
   Pre-Pennsylvanian (?), near Ta-miau-ssï (station 9).

Schuchertella ? sp. Girty (p. 307).

9. Dorsal (?) valve, × 3.
   Pre-Pennsylvanian (?), near Ta-miau-ssï (station 9).

Chonetes aff. C. flemingi Norwood and Pratten (p. 318).

10. Ventral valve, × 2.
    Pennsylvanian, Yön-yi-ssï, Shan-si (station 20).

Chonetes sp. Girty (p. 318).

11. Ventral valve, × 2.
    Pennsylvanian, near Yen-chuang, Shan-tung (station 69).

Marginifera ? sp. Girty (p. 320).

12. Ventral valve.
13. A crushed ventral valve.
    Pennsylvanian, near Yen-chuang, Shan-tung (station 69).

Productus ? sp. Girty (p. 319).

14. Dorsal valve, × 2.
    Pennsylvanian (Wu-shan limestone), near Ta-ning-hién (station 2).
15. Another dorsal valve.
    Pennsylvanian (Wu-shan limestone), near Liang-ho-k'óu (station 7).

Spirifer blackwelderi Girty (p. 320).

16. Internal mold of a ventral valve.
    Pennsylvanian (Wu-shan limestone), near Ta-ning-hién (station 1).
17. Internal mold of a dorsal valve.
    Pennsylvanian (Wu-shan limestone), near Ta-ning-hién (station 2).

Notothyris willisiana Girty (p. 324).

18. Side view.
19. Anterior view.
20. Dorsal view.
    Pennsylvanian (Wu-shan limestone), near Liang-ho-k'óu (station 7).

Hemiptychina ? aff. H. orientalis Tschernyschew (p. 324).

21. Dorsal view of crushed specimen.
    Pennsylvanian (Wu-shan limestone), near Liang-ho-k'óu (station 7).

DESCRIPTION OF PLATE 29—Continued.

Dielasma ? cf. D. elongatum Schlotheim (p. 327).

22. A dorsal valve of not quite medium size, showing the muscular imprints.
23. A small dorsal valve of somewhat different shape.
24. A small ventral valve.
    Post-Pennsylvanian (?) (K'ui-chóu series), near Ta-ning-hién (station 5).

Aviculipecten ? richthofeni Girty (p. 328).

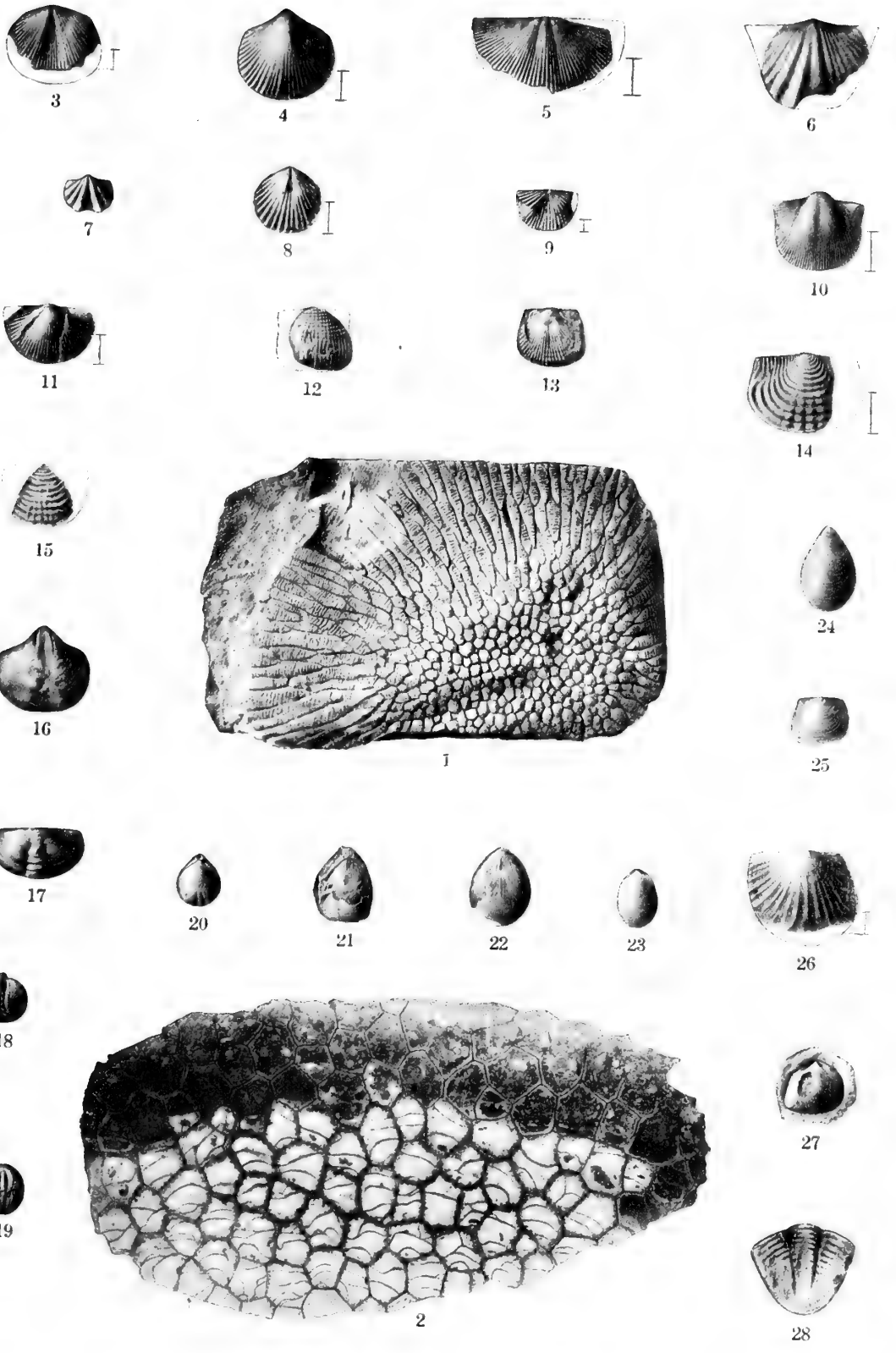
25. Right valve.
26. Left valve, × 4.
    Post-Pennsylvanian (?) (K'ui-chóu series), near Ta-ning-hién (station 5).

Schizodus cf. S. curtus Meek and Worthen (p. 325).

27. Internal mold of a right valve.
    Pennsylvanian (Wu-shan limestone, near middle), near Ta-ning-hién (station 16).

Phillipsia sp. (*a*) Girty (p. 326).

28. A somewhat crushed and worn pygidium.
    Pennsylvanian (Wu-shan limestone), near Ta-ning-hién (station 2).



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